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IMPROVEMENTS IN THE ART OF MANUFACTURING AND UTILIZING COAL TAR PRODUCTS.*

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Coal tar has long been known as the parent substance from which a multitude of products of industrial, as well as of purely scientific, significance are derived. No other material has so largely contributed to that brilliant achievement represented by the known chemistry of aromatic compounds. Its constituents have for a century served to stimulate research of the highest order. In it there occur readily available and in large quantities the fundamental substances about which practically the entire structure of aromatic chemistry has been reared. Although hundreds of components have been identified and many studied extensively, coal tar and its derivatives are still outstanding in their capacity to yield to imaginative investigators generous rewards in new compounds, new reactions and properties, and new uses.

Refiners are rapidly improving upon conventional methods of recovery and purification; materials until recently available only in laboratory quantities are now produced on an industrial scale; new outlets are being created as well for old as for new products; improved methods of application are

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being offered to consuming industries; the fields of utilization are broadening steadily.

No detailed review of these activities can be given in this necessarily limited presentation; it is purposed rather to indicate the magnitude of the industry and its major markets, to discuss the broader aspects of the distillers problems and to point out certain representative developments which comprise advances in the art.

Some of the improvements are directly related to the operations by which tars are produced; brief mention is therefore made of the more important sources; the principal types of crudes are also differentiated. Reference to the so-called low temperature or primary tars will be omitted since low temperature carbonization has not yet achieved commercial importance in the United States.

Coal tar is one of the by-products recovered from the gas produced by destructive distillation of bituminous coal in closed chambers or retorts. The gas leaving the apparatus contains the material largely in vapor form; on cooling the tar is condensed, is separated and collected in tanks as a more or less viscid black liquid.

Retorts are of three general types, the horizontal, the vertical and the horizontal by-product coke oven; each is a closed chamber constructed of refractory material externally heated.

Horizontal and vertical retorts are employed almost without exception for the production of domestic and industrial fuel gas, the coke being sold as fuel or utilized in the production of water gas. The coke oven serves primarily for the production of metallurgical coke, the gas in excess of that required for heating the ovens being consumed as fuel at steel mills or as domestic gas; in recent years several coke oven batteries have been installed by gas manufacturers to supplement the older horizontal or vertical retorts and water gas sets.

The estimated amount of coal coked and tar produced annually in the United States during the period 1927–1931 inclusive is shown.

By-product coke ovens produce approximately 92 per cent. of the total coal tar. While no accurate data on vertical

	1927.	1928.	1929.	1930.	1931.	5 Year Average.
Total coal coked (tons)	67,740,000	74,876,000	80,860,000	69,270,000	50,350,000	68,600,000
Coal coked by-product ovens	63,240,000	70,166,000	76,760,000	65,520,000	46,850,000	64,500,000
Coal coked horizontal and vertical retorts	4,500,000	4,710,000	4,100,000	3,750,000	3,500,000	4,100,000
Total tar produced (Gals.)	601,000,000	688,500,000	728,300,000	647,500,000	467,000,000	626,450,000
Coke oven tar	547,000,000	632,000,000	681,000,000	602,500,000	425,000,000	577,500,000
Horizontal and vertical retort tars	54,000,000	56,500,000	47,300,000	45,000,000	42,000,000	48,950,000

Note: The above statistics were obtained from the following publications: U. S. Dept. of Commerce, Bureau of Mines bulletin "Coke and By-Products" in 1927, 1928, 1929, 1930. U. S. Tariff Commission Report "Census of Dyes," 1930.

retorts are available it may safely be stated that they produce only a very small proportion of the remaining 8 per cent.

Water gas tar, derived from petroleum oil rather than from coal, is a crude important to the tar distiller; it contains considerable quantities of aromatic compounds and on distillation yields oils and pitches sufficiently like the coal tar products to complement them industrially. The average annual production of water gas tar over the above period is estimated to have been approximately 100,000,000 gallons.

It is estimated there were also produced at coke oven and gas plants 180,000,000 gallons per year of coke oven light oil and drip oil, these materials being recovered from the gas following removal of the tars.

Not all of these products were marketed. It is estimated that 315,000,000 gallons of all tars were burned yearly as liquid fuel. The average quantities of crudes available annually to the industry during the period mentioned are estimated to have been:

Coke Oven Tar	287,500,000 gals.
Horizontal and Vertical Retort Tar	48,950,000 gals.
Water Gas Tar	75,000,000 gals.
Crude Light Oils	180,000,000 gals.

Not all coal tars are alike; their character and composition are directly affected by the following major factors:

1. The type of chamber of retort.
2. The coal coked.
3. The temperature to which the gases are exposed.
4. The time of such exposure.

Water gas tars likewise differ in character, depending upon:

1. The type of water gas machine.
2. The petroleum oil used for carburetion.
3. The method of operation.
4. The temperature in the reaction zones.
5. The rate of gas making.

The following general statements respecting the basic characteristics of coal tars may be made:

Exposure of the coal distillation gases to high temperatures

tends to produce tars rich in free carbon, high in specific gravity and viscosity and containing relatively large amounts of naphthalene, as well as comparatively small amounts of tar acids. Such crudes on distillation yield relatively large percentages of pitch and correspondingly small percentages of the lower boiling coal tar oils; these oils contain relatively low percentages of naphthenic, aliphatic and unsaturated aromatic compounds. Of the tar acids present, phenol, the cresols and the xylenols predominate. The longer the period of exposure to high temperatures the more pronounced the above characteristics become.

The lower the temperature of coking and the shorter the period to which the gases are exposed to that temperature, the more prominently will the tars be distinguished by:

a. Low free carbon content.
b. Low specific gravity and viscosity.
c. Relatively high percentage of naphthenic, aliphatic and unsaturated aromatic hydrocarbons.
d. Relatively low naphthalene content.
e. High percentage of tar acids, particularly those of high boiling range and those having long aliphatic side chains; phenol, the cresols and the xylenols being present only in small amounts.

On distillation these tars yield comparatively low percentages of pitch and high percentages of low boiling distillates rich in phenolic and unsaturated constituents.

The different coal distillation units described produce strikingly individual tars. In vertical retorts the gas is exposed to comparatively low temperatures (1100° F. to 1300° F.) for only a very short time and is cooled rapidly. The tars produced are of low free carbon content and of low specific gravity and viscosity. They yield distillates rich in unsaturated and phenolic constituents and low in naphthalene. The pitch yield is relatively small and the material is of low free carbon content; it is unsatisfactory for many industrial uses due to its peculiarly brittle character.

Coke ovens are operated at temperatures ranging from 1400° F. to 1600° F. The gas is generated at a high rate and exposed for only a brief period to the extremes of temperature.

The tars are of intermediate free carbon content and of medium specific gravity and viscosity. They contain considerable naphthalene and phenol, cresols and xylenols; they yield distillates of high specific gravity. The pitches are of intermediate free carbon content and are suitable for the great majority of industrial uses.

Horizontal retorts are operated at high temperatures (1600° F. to 1900° F.) to which the gases are exposed for a comparatively long period. The tars are therefore distinguished by:

a. High free carbon content.
b. High specific gravity and viscosity.
c. High percentage of naphthalene.
d. Intermediate tar acid content with phenol, cresols and xylenols predominant.
e. Low content of naphthenic, aliphatic and unsaturated hydrocarbons.

They yield distillates of high specific gravity, deficient in low boiling oils. The pitches are of exceptionally high carbon content. These tars are usually blended with coke oven tar for the purpose of increasing the free carbon content of the coke oven tar pitch.

It is to be realized that conditions vary widely from plant to plant. Hence certain coke oven batteries operating at high coking rate and having ovens in which the gases are exposed for the minimum time to surfaces at high temperature may produce tars quite similar to vertical retort tars. Likewise coke ovens operated under conditions allowing long exposure of the gases to high temperature may produce tars much like those from horizontal retorts. Variations in construction and operation of horizontal retorts may also cause tars to vary from those much like coke oven tar to those of high specific gravity and viscosity and containing as much as 33 per cent. free carbon.

Water gas tars are distinguished chiefly by their high content of aliphatic hydrocarbons and their freedom from phenolic and nitrogen compounds. Until recently they were typified by low specific gravity and viscosity, extremely low free carbon content and by the relatively small yield of

Characteristics of Various Types of Tars.

	Coke Oven Tar.	Horizontal Retort Tar.	Vertical Retort Tar.	Water Gas Tar.	
				Old.	New.
Specific Gravity @ 25° C./25° C.	1.14–1.20	1.20–1.23	1.11–1.17	1.00–1.10	1.13–1.21
Viscosity, Engler 100 cc. @ 40° C.	230–1000 sec.	Too viscous @ 40° C.	200–1000 sec.	30–80 sec.	500–4000 sec.
Free Carbon %	3.0–8.0	14–33	1–4	0.3–2.0	5.0–12
Tar Acids %	1–12	0.3–6.7	5.0–15.0	None	None
Distillation % to 170° C.	0–1.0	—	2–4	1.0–3.0	0.5–2.0
% to 235° C.	6–11	1.5% to 205° C.	—	7–33	3.0–8.0
% to 300° C.	20–25	25	27–40	30–60	19.0–30.0
Pitch Residue %	75–80	75	60–70	40–70	70–80
M. Pt. ° F.	120–150	145	135–150	125–140	160–185

pitch recovered by distillation. The last two years have seen a most striking change in water gas tars due to the substitution by gas makers of heavy petroleum fuel oil for the well-known gas oil previously used for carburetion. The newer tars are of relatively high specific gravity and viscosity and contain high percentages of free carbon. These tars yield less low boiling distillates than do the older gas oil products; it is impossible to produce from them low carbon pitches similar to those manufactured from the earlier low carbon water gas tars.

The foregoing statements indicate that tars are subject to considerable fluctuation in composition. It is the responsibility of the distiller to process these heterogeneous crudes in such a manner that the consumer may adequately be supplied with products not only uniform in character but of high quality. Further it is the responsibility of the refiner to so advance the state of his art that markets for staple products may be maintained and expanded in the face of competition from without, that new outlets may be created and that demands for new products may be met.

The materials marketed by the coal tar industry may for the purposes of this discussion be regarded as comprising five major classes:

	Gallons Marketed Annually.*
1. Refined Light Oils	160,000,000
2. Refined Tars including Road Tars	128,000,000
3. Pitches	121,000,000
4. Distillate Oils	127,000,000
5. Chemicals	6,000,000

* Based on statistics in U. S. Tariff Commission Report "Census of Dyes" for 1930.

Approximately 95 per cent. of the refined light oils are derived from crude coke oven light oil and drip oil; approximately 95 per cent. of the remaining materials are recovered from tar.

It is to be realized that in making such a division no sharp lines of distinction can be drawn. The proportion any single class bears to the whole may fluctuate widely. Nevertheless the figures are sufficiently accurate for the more fundamental groups of the industry's products and for evaluating certain of the developments to be discussed.

Refined coal tar light oils comprising benzene, toluene, the xylenes, motor benzol and various solvent naphthas, may be regarded as substantially the only so-called coal tar products of major importance which are not produced principally from coal tar itself. They are obtained from three sources, crude coke oven light oil, drip oil and light oil distillate from tar. Coke oven light oil representing approximately 95 per cent. of the crudes is usually processed at the coke plant or at central refineries owned by the coke oven operator. The drip oils and light oils from tar are commonly handled by tar distillers.

The conventional method of refining these oils comprises washing with sulphuric acid with subsequent fractional distillation for recovery of the desired components.

Most refiners have within the last two or three years sharply improved control over their processes. The success of their efforts has been evidenced by improvement in quality of finished products, particularly with respect to elimination of unsaturated bodies and organic sulphur compounds which together are responsible for darkening of color, for offensive odors, for low yields in subsequent chemical operations and for unsatisfactory quality of products in which the oils are utilized as solvents. In many cases the sulphuric acid treatment has been improved by limitation of the concentration of the acid and particularly by careful temperature control during washing. Reduction to the practical minimum of the temperature to which the washed oil is exposed in the distillation operation is of importance in avoiding contamination of distillates by unsaturated compounds resulting from decomposition of the more sensitive impurities present. The use of mild chemical treatments for the removal of sulphur bodies from the refined distillates has become widespread.

Improvements of the type mentioned have in general resulted from a growing demand on the part of consumers for products of qualities considerably higher than those until recently accepted as satisfactory.

One highly purified material deserves special mention. Recently industrial uses for thiophene-free benzene have been developed. Benzene not only free from thiophene but of reagent grade in other respects is now produced in large quantities.

Of the 160,000,000 gallons of refined light oils sold annually, 60 to 70 per cent. comprises motor benzol which is ordinarily blended with gasoline to produce a motor fuel of high anti-knock value. Motor benzol has commonly been produced by washing the crude fraction with sulphuric acid and distilling. Gum forming constituents have thus been eliminated. Unfortunately the washing operation destroys relatively large quantities of materials which cause no trouble as gum formers and would be perfectly satisfactory as motor fuels. Much research has been conducted in an attempt to develop economical means for eliminating gum forming constituents without sacrificing these other valuable components.

Several practical procedures have been evolved. Some retain sulphuric acid as the washing reagent but carefully regulate its amount and concentration as well as the temperature of washing. Several modifications of this method have been successfully employed. Others utilize silica gel, clays, etc. In the silica gel process [1] the oil is first treated with a limited amount of sulphuric acid, is then contacted with the gel, and finally neutralized and distilled. Another method involves agitation of the oil with clay impregnated with an active reagent such as iron persulfate, followed by neutralization and distillation.[2] The National Benzol Association of Great Britain approached the problem from a different angle. Their researches [3] disclosed that certain organic compounds added in small amount to freshly distilled crude motor benzol inhibit the formation of gums without adversely affecting the quality of the oil as a motor fuel. Without going into further detail it may be stated that each of the methods mentioned is capable of producing motor fuel of satisfactory quality and yield.

These developments represent in aggregate an important advance over previous methods of producing motor benzol; they are of little if any utility as respects benzene, toluene, the xylenes and other refined light oils not employed as motor fuels.

[1] *Journal of Industrial and Engineering Chemistry*, Vol. XXI, pp. 691–693, 1929.

[2] U. S. P. 1,658,285, 1,742,343.

[3] Report of Benzole Research, The National Benzole Association, Years 1926–1929 incl.

Items within the remaining groups of products marketed by the industry, namely, refined tars, pitches, distillate oils and chemicals are with few exceptions derived from tar. It is with these products that the refiner is principally concerned.

Although the subject under discussion has to do with the more technical phases of tar refining, certain economic problems which beset the industry, will be pointed out since some of the advances in the art have resulted from efforts directed toward their solution.

Notwithstanding the fact that the volume of tar produced in the United States is more than adequate to supply all domestic requirements for coal tar products and that in aggregate refiners have installed manufacturing capacity sufficient for all needs, large quantities of important tar derivatives are imported annually from European countries; there are ordinarily no corresponding exports. The imported items of importance are creosote oil, crude naphthalene and cresylic acid. Irrespective of factors such as quality, cost, terms of sale, etc., one of the fundamental reasons for this anomalous situation resides in the fact that in Europe pitch for use in the briquetting of coal is from the standpoint of tonnage for European consumption the most important coal tar product.

Briquette pitch may be regarded as the back-log of the European tar industry. The distiller manufacturing it must also produce those coal tar distillates which in the main comprise creosote oil and which also are the source of cresylic acids and naphthalene. Unfortunately the European consumption of creosote is far below the production; the distiller's only other substantial home outlet is the fuel oil market which yields him highly unsatisfactory returns; he therefore expectantly turns for relief to the United States creosoting industry. For many years he has enjoyed a demand for practically all the briquette pitch he could produce and until comparatively recently has been able to sell the major portion of his excess creosote oil in this country. This disposition of his tar yielded a satisfactory return and as a result, the European distiller expended little energy in the creation of new home outlets for tars and derivatives which would avoid

the necessity for production of creosote oil. As a specific example the market for road tars has been given relatively little attention. Although individual refiners have sold limited quantities of those materials there has until recently been little coördination of effort on the part of the European industry to promote the production of thoroughly standardized high quality road tars such as those which have for many years been widely used in the United States.

Naphthalene and cresylic acids which occur in the lower boiling creosote fractions also find in Europe a market considerably less than the amounts which can economically be recovered from the large excess of creosote available. The producer again looks to the United States for disposition of a large proportion of these materials.

The situation confronting the American distiller is quite different. The use of road tars has been developed along constructive lines over a period of at least 20 years. There is in the United States practically no consumption of briquette pitch; ordinarily very little pitch is exported. Occasionally shortages in Europe are filled from this country; that outlet can, however, not be depended upon by the domestic distiller as having permanence. Normally, there is an annual consumption of 200,000,000 to 225,000,000 gals. of creosote oil in the United States. European distillers have until recently supplied 35 to 45 per cent. of the requirements.

That product may be regarded as the back-log of the domestic industry. Pitch of the character recovered in producing creosote represents a burden to the distiller; even though it can be sold in large quantities for use as fuel the returns are in most cases so low that such sales represent net losses.

The refiner faces the further disadvantage that in many cases the unit ocean freights from European ports to principal United States creosoting districts are lower than the corresponding unit rail and water freights on shipments of domestic oil from the important producing centers.

Large quantities of coke oven tar are available in the Birmingham, Ala., district which is adjacent to the most important creosote consuming area in the United States. There is, however, in that locality only a very limited market for

road tars and pitches and a still smaller outlet for coal tar chemicals. To operate at a profit the distiller in that area must limit his production of creosote to an amount corresponding to the pitch which he can sell. The net result is that next door to the greatest creosote market in the world, 40 to 50 per cent. of the coal tar available is burned as fuel at local steel mills. The tar so consumed would produce approximately 15,000,000 gallons of creosote oil. Approximately 60,000,000 gallons of European creosote has in recent years been consumed annually in the states adjacent to Alabama.

Because the amount of creosote which he can profitably sell is distinctly limited the refiner's output of the important coal tar chemicals—naphthalene and cresylic acid—is also restricted. One basic problem of the domestic distiller is then to find economical means for disposing of pitch. Having such means the industry will find it possible to supply the entire United States requirements of creosote oil and important chemicals such as naphthalene and cresylic acids.

The European refiner likewise must find outlets for tar other than in the form of briquette pitch and creosote. Great Britain, the principal European creosote producer and exporter consumes practically no tar as fuel. The United States burns annually an amount considerably in excess of that equivalent to the principal coal tar products imported.

The domestic distiller has within the last five years made considerable progress toward the solution of the problems mentioned. Improved methods for refining tar have been developed; means for disposition of worthwhile quantities of pitch are now available.

It must be realized that the most important process employed by the industry is that of distillation. Practically all tars are subjected to that treatment; few if any of the principal derivatives reach the finished state without at least one distillation; some require several. Initially the tar refiner employed simple batch-type stills—fire heated tanks equipped with vapor lines and condensers for recovery of oil fractions. Many are in use today at small plants.

About twenty years ago The Barrett Company at its larger refineries initiated in this country the use of continuous

tube-stills for tar distillation. In that equipment tar under pressure is pumped through fire heated tubes. The heated material discharges into a flash box and the vapors liberated from the tar pass to condensers, the pitch running to receiving tanks. Due to avoidance of local superheating and exposure for long periods to high temperatures, tars processed in the continuous stills yield more oil to pitch of any given melting point than when treated in simple stills.

The distillates originally were recovered by stepwise cooling of the vapors in multi-stage condensers; relatively wide boiling oils resulted. The wartime growth of the tar industry necessitated improvement in the quality of lower boiling oil fractions in order that the subsequent recovery and purification of products such as naphthalene and tar acids might be simplified. Continuously operating fractionating columns were added to the tube stills; sharply defined oil cuts resulted. Stills of the general type described have come into common use throughout the industry. They serve for the production of creosote oil and of pitches of melting point as high as 250 to 280° F., but are not well adapted to the manufacture of extremely hard pitches, e.g., of 400° F. melting point. One method developed by The Barrett Company for obtaining the latter material involves the use of fire heated batch stills in which the removal of the oils is assisted by the recirculation of inert gases through the liquid mass undergoing distillation thence to condensers and back to the still.[4]

The Barrett Company has further improved the continuous still by the application of a secondary vacuum stage.[5] The pitch discharging continuously from the flash box of the still contains residual heat adequate for considerable further distillation of oils, if exposed to high vacuum. One modification involves the installation of a secondary vapor box operated under high vacuum; the pitch from the first vapor box is drawn continuously into the vacuum box in which the oil vapors flash off and are removed through condensers. Pitch of 400° F. melting point can be made continuously without difficulty. Likewise lower melting point products

[4] U. S. P. 1,418,893.
[5] U. S. P. 1,759,816.

can be recovered at overall temperatures considerably below those in the usual tube-still operated at atmospheric pressure. This still as compared with equipment operated at higher temperature yields more distillate oil and less pitch of any given melting point; the pitch is of relatively low free carbon content. The development of the continuous vacuum-still represents a distinct advance in the art of refining tar.

A few years ago The Barrett Company concluded that departures from conventional methods of treating tar must be made if the desired degree of freedom to supply its own markets for the more important products were ever to be realized by the domestic industry. It was unreasonable to expect that new demands sufficient in extent to consume the great burden of the harder pitches could be created rapidly enough to enable the refiner to maintain his position in the face of increasingly severe competition from abroad. It appeared quite evident that realization of potential reductions in operating costs at existing plants would fall short of accomplishing the desired results since the expense of transporting tar from coke oven to distillation plant and cost of handling and disposing of pitch would still represent a serious burden. Solution of the problem appeared to involve the installation at strategically located coke oven plants of distillation equipment capable of producing, at minimum cost, road tars, creosote oil and pitches. Preferably, the plant should be capable of producing for sale creosote oil alone—in other words, it should itself consume all pitch manufactured.

The location of conventional distillation units at or adjacent to coke plants was by no means novel, since several refineries were already receiving tar by pipe line from producers' tanks and in some cases were actually located within the confines of the coke plant.

Consideration of the various phases of the problem led to the belief that with the exception of a few unusual cases no adequate solution could result from the utilization of then available distillation equipment and methods.

Studies were made to determine whether in the development of new and advanced means for processing tars at coke ovens advantage might be taken of existing equipment or

conditions. These investigations led to comprehensive researches, from which have resulted several processes for recovering finished tar products at the source. These radical departures from the conventional are today recognized generally as the "Direct Recovery Processes" of The Barrett Company.[6]

No discussion of the intimate details of these extensive developmental projects can be undertaken here; only the more significant findings will be mentioned. Although the apparatus and methods are readily adaptable to coal and water gas plants generally, they will be described from the standpoint of their use at by-product coke ovens.

Coke ovens are operated at temperatures of the order of 1400° F. to 1600° F. The coal distillation gases which ordinarily amount to from 11,000 to 14,000 cu. ft. per ton of coal coked commonly leave the retorts at 1000° F. to 1200° F.; they contain in vapor form water, coal tar light oil and the hydrocarbons comprising tar. Coal and coke dust, carbon and pitchy material in extremely fine state of subdivision occur as entrained particles. The other components including ammonia may be regarded as fixed gases.

The highly heated gas is commonly conducted from the ovens into large headers or collector mains. Copious quantities of tar or ammonia liquor or both are sprayed into these mains for the purpose of rapidly cooling the gas and for flushing away any solids which may temporarily have accumulated.

The partially cooled gas is then delivered to condensers in which its temperature is lowered to about 50° C. as the

[6] Direct Recovery Patents illustrative of various phases of the field involved:

U. S. Patents

1,752,920, 1,807,223, 1,811,953, 1,812,829, 1,825,809, 1,826,428
1,826,429, 1,826,430, 1,826,431, 1,826,561, 1,844,741, 1,844,889
1,844,890, 1,844,891, 1,844,892, 1,844,893, 1,844,894, 1,844,895
1,844,896, 1,844,897, 1,844,898, 1,844,899, 1,844,900, 1,844,901
1,849,197, 1,849,198, 1,849,199, 1,862,493, 1,862,494, 1,868,394
1,868,395, 1,868,470, 1,871,550, 1,871,596, 1,871,628, 1,883,642
Other applications pending.

British Patents

282,367, 347,240, 349,088, 370,387, etc.
Protected in other foreign countries.

maximum or 25° C. as the minimum. In this cooling process the tar which ordinarily amounts to from 8 to 10 gallons per ton of coal coked is condensed together with more or less ammonia liquor; the coke oven light oils remain in the cooled gas as vapors. Commonly the ammonia liquor is decanted from the tar which after further dehydration comprises crude tar for the distiller or fuel for the steel mill. This represents the common method of recovery at coke plants.

The "Direct Recovery Processes" as related to coke oven operations are founded upon certain conditions which obtain during the coking operation.

1. The hot coal distillation gas as it emerges from the retort is highly superheated as respects its normal dew point for the hydrocarbon oils present as vapors.
2. In unit quantity of the gas emerging from the oven, the heat represented by the superheat above the normal dew point of the gas for creosote oil is adequate for the distillation of several times the amount of tar contained in that unit quantity of gas.
3. If the highly superheated gas be cooled stepwise the condensate first appearing will be a high melting point pitch; as cooling progresses, lower and lower melting point pitches appear; then liquid tars and finally tarry oils separate.
4. If immediately following any specified cooling stage the gas be freed of entrained solids and liquids the oils recovered on subsequent cooling will be clean oils, i.e., free from carbon and the pitchy materials responsible for dark color.
5. Gas generated during the earlier coking stages contains relatively high percentages of light tar characterized by low carbon content and low specific gravity and viscosity. As coking progresses, the rate of gas generation falls off, the percentage of tar decreases and the tar itself is characterized by increasingly high carbon content, and high specific gravity and viscosity. The tars from the early or "rich gas" yield relatively small amounts of pitches low in free carbon and correspondingly large amounts of low boiling distillates; tars from the late or "lean gas" yield relatively large

amounts of high carbon pitches and correspondingly reduced quantities of distillates of high specific gravity and boiling range.

Broadly these conditions permit of two methods for recovery of a variety of tars, pitches and oils. In one, the result is accomplished by cooling the gas in regulated manner with cleaning if clean oils be desired. The pitches and oils are separated at appropriate temperature levels. In the other, highly heated gas is employed to distill directly very considerably more tar than it normally contains. The gas greatly enriched in oil vapors is cleaned and on cooling yields clean oil in amount far above that ordinarily present. Various modifications of the individual methods and combinations have been developed.

The distillation method involved the handling of only relatively small quantities of hot gases, called for apparatus moderate in size and cost and in general seemed more closely to meet specified requirements than did the method characterized by regulated cooling and cleaning of the normal coke oven gas.

Of the several processes evolved one in wide commercial use is briefly described.

The highly superheated gas emerging from a limited number of selected coke ovens is delivered continuously through a heavily insulated header to the distillation main or still. Entering this main at substantially the temperature at which it leaves the ovens (1000 to 1200° F.), the gas is copiously showered with tar. Its temperature is instantaneously and sharply reduced; its superheat is expended in the heating and distillation of the tar to pitch which overflows continuously from the still. It may readily be seen that by controlling the amount and temperature of the tar showered into unit quantity of the gas, the extent of gas cooling as well as the degree of distillation of the tar may be regulated. The gas leaves the distillation main saturated with the highest boiling oils vaporized from the tar but is still distinctly superheated as respects the intermediate and lower boiling oils. In its passage through the still the gas is so thoroughly drenched with tar and pitch in the form of minute droplets that practically all entrained matter is removed. From the

main the gas enters and rises through a packed chamber known as the "hot-gas-saturator"; raw or preheated tar showered into the chamber flows down over the packing, countercurrent to the gas, which becomes saturated with the tar oils of intermediate and lower boiling range. Any entrained pitch spray is washed from the gas by the tar, which collected at the base of the saturator is run continuously to the still and comprises the tar feed to that equipment. The saturated gas passes through a short section of dry packing for removal of last traces of entrained tarry matter and then enters a heat interchanger. Raw tar flowing through tubes in this apparatus is preheated before its discharge into the hot-gas-saturator. The gas is somewhat cooled; a fraction comprising the higher boiling oils is condensed and drawn off. The gas then passes to the final condensers which may be of the indirect water-cooled variety or of the direct type in which the cooling is accomplished by means of ammonia-liquor sprays. The condensed oils and ammonia liquor are conducted to decantation tanks for separation. The cooled gas free of distillate oils is disposed of by diverting it to the main stream of gas from the ovens not employed for distillation.

The process has many features of interest. It is strictly continuous. No fuel is required for distillation. Tar collected at the coke plant in the normal manner or that from outside plants may be distilled. The distillates recovered are clean; the appropriate oils may readily be extracted with caustic soda for recovery of tar acids. Sharply defined fractions are provided for by the addition at selected points in the system of suitable packed towers and the refluxing of appropriate hot oils through them. Residual products ranging from only lightly distilled tars to pitches of melting point of 400° F. or higher are readily produced in a strictly continuous manner; a variety can be recovered simultaneously. Road tars and other refined tars are manufactured without difficulty. Due to the fact that the tar or pitch is exposed for only an instant to maximum gas-temperatures and that all subsequent temperatures are considerably lower than those normal to conventional processes, less decomposition occurs and higher yields of oil are obtained than by those con-

ventional methods, particularly as respects the production of harder pitches. Likewise these products are of relatively low carbon content.

Such hard pitches, e.g., of 280° to 400° F. melting point, are, if desired, disposed of at the coke plant by blending the finely divided material with the coal charged to the ovens. The pitch from all of the tar produced by any battery of ovens may be returned to the coal charged to that battery. The hard pitches may likewise be fluxed with heavy oil or with tar to yield a wide variety of so-called cut back pitches. Change from material of one melting point to another may be accomplished almost instantly by varying the ratio of tar to gas feed.

The apparatus is compact, is readily adaptable to the various types of coke ovens and occupies only a small space on top of the oven block. It does not interfere with the normal functioning of the coke plant.

The operation is simple to control. While the process is strictly continuous the apparatus may be shut down within a few minutes and likewise may as readily be started up.

The distillation main deserves mention. In its simplest form it is a horizontal chamber with gas inlet and outlet at opposite ends. By means of an adjustable overflow a shallow pool of pitch is maintained. A horizontal cylindrical roll approximately 12″ in diameter is located lengthwise within the still, its lower surface extending approximately 1″ into the pitch. The roll rotating at 900 to 1200 R.P.M. creates a tremendously copious shower of fine droplets of the latter material. The tar fed to the still instantaneously blends with the pitch; distillation is effected by the hot gas. This shower of pitch serves three fundamentally important purposes: it effects instantaneous reduction of temperature of the highly superheated gas; it drenches with pitch all exposed metal surfaces and prevents formation of coke thereupon; it washes from the gas all entrained dust, carbon and pitch or matter which otherwise would prevent recovery of clean distillates.

The capacity of the Direct Recovery unit to distill tar may be visualized from the following representative data, based upon a 60 oven coke plant coking 1200 tons of coal per day and producing daily 10,000 gallons of tar. The number

of ovens supplying gas for distilling all the tar to each one of several pitches is indicated.

No. Ovens Used.	M.Pt. Pitch Produced.	Gals. Tar Distilled per Ton Coal Coked in Ovens Used.
3	105° F.	160 to 180
4	150°	120 to 135
5	225°	100 to 110
6	400°	80 to 90

Capacities vary from plant to plant depending upon rate of coking, construction of ovens, temperature of tar feed and other factors. The figures indicating tar distilled per ton of coal coked include that present in the gas emerging from the ovens; this comprises from 5 to 10 per cent. of the total.

Direct Recovery units have been installed at eight coke oven plants in the United States and at one in Mexico. The United States plants in aggregate are capable of distilling 36,000,000 gallons of tar annually to produce tar acid oils, creosote oils and a variety of residuals ranging from lightly distilled tars to pitches of 400° F. melting point.

The "Direct Recovery Process," a radical departure from the conventional methods of refining tar, represents an important advance toward the solution of certain of the troublesome problems facing the domestic industry.

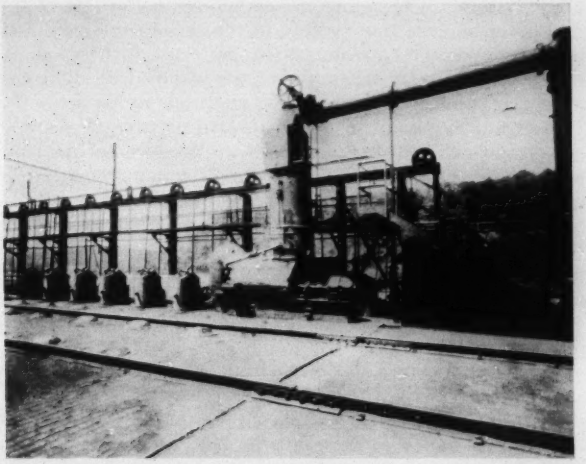
Two specific examples of the industrial utilization of hard pitch deserve mention.

Material of 300 to 400° F. melting point serves as a highly satisfactory powdered fuel for the direct firing of rotary lime kilns. Its extremely low ash content makes pitch of particular interest for such purposes. That marketed by The Barrett Company is in the form of flakes produced on rotating cooled drums or more recently on moving water cooled metal belts.[7]

Another use has developed from the fact that the recent installation of several thousand miles of steel pipe for conducting natural gas has required coatings for protection against corrosion. Coal tar pitch, one of the most satisfactory among many competitive materials employed for the purpose, has been used in large quantities by line builders. The coating operation is ordinarily conducted along the right of way just prior to lowering the line into the trench. Molten

[7] U. S. P. 1,807,223.

pitch enamel of approximately 190° F. melting point is applied to the previously primed pipe. This enamel usually contains a mineral filler which reinforces it against distortion due to soil pressure and against puncture by clods, stones, etc., during the backfilling of the trench. Pitch of the melting point indicated is a hard seemingly rigid product; it nevertheless is subject to plastic flow under constantly applied soil pressures, although to a considerably lower degree than other bituminous materials. It is therefore common practice to



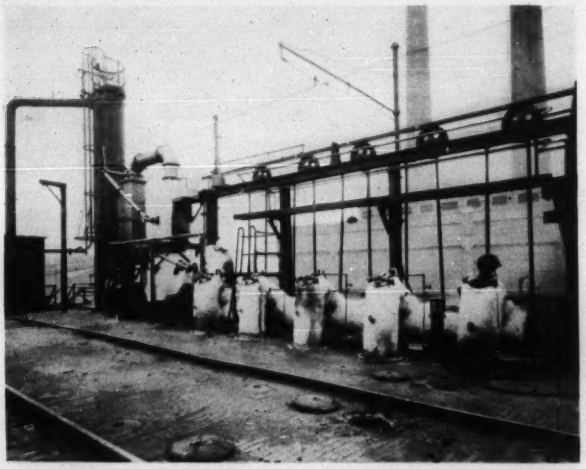
DIRECT RECOVERY UNIT.—Left to right; Uptakes and hot gas header, distillation main, hot gas saturator and preheater.

protect the enamel against deformation; a wrapping of tar-saturated asbestos felt serves well.

Probably the rate of installation of new main lines for natural gas will ultimately fall to the point at which only comparatively small tonnages of enamels will be required annually; it is, however, to be expected that considerable amounts will be consumed in reconditioning of old lines, in the protection of feeders from main lines and in the coating of local distribution systems.

In addition to the development of new uses it frequently becomes desirable for the refiner to work out improved methods by which consumers of his products may obtain results superior in degree to, or at costs lower than, those ordinarily realized. A project of that nature recently completed by The Barrett Company is of interest. Improved processes and apparatus for the impregnation of the well-known fibre conduits with pitch or other bituminous material have been developed.

Porous articles have commonly been saturated with pitch

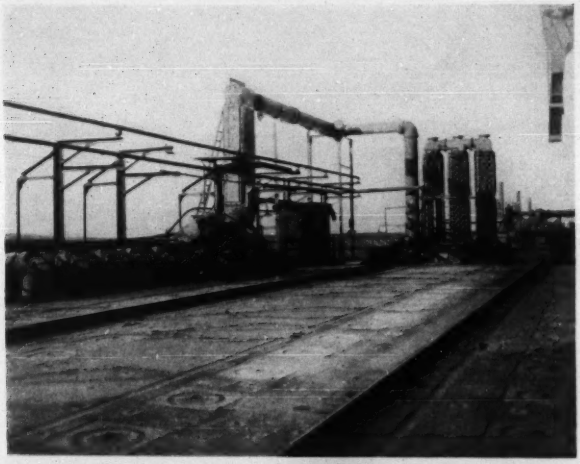


DIRECT RECOVERY UNIT.—Right to left: Uptakes and hot gas header, distillation main, hot gas saturator, preheater, direct condenser.

by processes involving treatment under super atmospheric pressure. It has been found that impregnation may more readily be accomplished if the operation be conducted at pressures considerably below atmospheric. The Barrett Company has recently developed a vacuum process which may be operated in a continuous manner. It functions without interruption of vacuum, involves no mechanically sealed closures, requires a minimum of power and yields in a

minimum time fibre conduits highly impregnated with pitch or other bituminous material.

A vertical tower closed at the top, of height sufficient to accommodate the maximum barometric column of the molten material and equipped at bottom with liquid sealing means, is employed. An endless conveyor carries the porous articles through the liquid seal up through the molten saturant, reverses, drops down, leaves through the seal and returns to starting position. To begin operation the molten saturant is



DIRECT RECOVERY UNIT.—Left to right: Uptakes and hot gas header, distillation main, hot gas saturator, fractionating tower and indirect condensers.

drawn into the tower to the desired level by means of vacuum of appropriate degree; the conveyor is then started. The completely impregnated products are removed from the latter after emerging from the sealing liquid at the end of the cycle. Certain articles requiring six to ten hours treatment by the older processes are readily impregnated in 30 minutes to 1½ hours by the method described. The apparatus is compact, low in initial and operating costs and as compared with that of older processes has an extremely high capacity per

unit of space occupied. While it has been outlined more particularly with respect to pitch and other bituminous materials it is, of course, equally workable with a wide variety of other saturants.

One additional outlet for pitch to which the industry has directed considerable attention is mentioned.

Refiners have long marketed coke obtained directly from tar in batch stills or indirectly by distilling pitch in a similar manner. Such material generally is relatively soft and of comparatively high volatile content. It has been consumed as domestic fuel, employed in the manufacture of carbon electrodes or exported for the latter use. The Barrett Company perfected the coking of high melting point pitch in beehive ovens, the volatile oils serving as the fuel for the operation.[8] A lustrous, dense, extremely hard product of very low volatile content and of superior quality results.

More recently others have developed methods for coking pitch or other bitumens in externally heated refractory retorts. The Knowles Process [9] involves the use of a specially constructed shallow sole-fired oven to which the bitumen is fed continuously and in which the coke gradually accumulates, finally to be pushed mechanically from the oven. It is understood that this equipment is in successful operation at petroleum refineries; so far as known it is not being employed with coal tar pitch.

A method of the Koppers Company [10] utilizes selected ovens in a coke-oven battery. Molten pitch is sprayed continuously down through the top of the highly heated retort; coke gradually accumulates and ultimately is pushed from the oven.

Both the Knowles and Koppers cokes are said to be of character intermediate the still and beehive products.

No attempt is made here to evaluate the various processes. Each provides a means for converting pitch to another salable form. The potentialities of any method of coking pitch appear with few exceptions to be delimited on the one

[8] U. S. P. 1,650,126.
[9] U. S. P. 1,879,983.
[10] British Patent 337,800.

hand by the corresponding petroleum products and on the other by by-product-oven coke, both available in large quantities, each a relatively low-priced commodity.

In addition to the products already discussed, there remains the group comprising the so-called coal tar chemicals the more important of which are naphthalene and tar acids.

Numerous advances in methods of manufacture of these derivatives are evidenced by a comparatively recent and substantial improvement in quality of finished products. With few exceptions these improvements reside in slight alterations in, and closer control over, the various steps of the old and well-known processes of recovery. The installation of highly efficient fractionating column stills has probably contributed most to the general betterment.

Although large amounts of cresylic acid and of crude naphthalene are imported annually, the domestic industry has made rapid strides in the recovery of increasingly larger quantities of the materials. While for economic reasons largely beyond his control the refiner is not at present filling all domestic requirements, it is believed safe to state that in the event of a national emergency consumers would today be not at all dependent upon any foreign country for supplies of these highly important coal tar products—a position arrived at within the last three years.

A new group of refined chemicals has recently been made available. The tar bases, pyridine, quinoline and their homologues have heretofore been manufactured by domestic producers only in the form of relatively crude fractions. The Barrett Company is now making a number of the refined materials on a commercial scale: pyridine, quinoline, isoquinoline, quinaldine, alpha picoline and close boiling fractions of the lutidines, all of domestic manufacture, are available to consumers.

Discussion of the chemicals closes with brief mention of the well-known paracoumarone resin.

Notable as substantially the only chemically inert resin available at low price it continues to find increasingly wide application in the paint, varnish, rubber and associated industries. Recently it has come into large scale use in the manufacture of composition floor tiling. Few other coal tar

products find their way as such into as wide a variety of outlets as does this material.

A considerably more intimate discussion than that presented would be required to indicate accurately trends within the industry. It may be stated that, in general, consumers are calling for materials of considerably higher quality than was the case no longer than two years ago. Many refined products such as naphthalene, tar acids and paracoumarone resin are required not only to meet the usual specifications but to behave in closely defined manner in the user's own operations; the refiner finds it necessary to manufacture a wide variety of highly specific materials. It is likewise true that consuming industries are today exhibiting keen interest in distinctly new coal tar derivatives which the refiner from time to time introduces.

The distiller is making a determined effort to develop new and extensive uses for bulk materials, such as the harder pitches, to the end that he may relieve existing markets for his important commodities of dependence upon foreign producers.

Substantial progress has been made in firmly establishing a domestic coal tar industry, not only adequate in capacity but having the resourcefulness requisite to meet all demands for its products.

Vitamin Content of Milk throughout the Year.—FLORENCE L. MACLEOD, JESSIE B. BRODIE, AND EMILY R. MACLOON (*Jour. of Dairy Sci.*, 1932, XV, 14–22) have made biological assays to determine the vitamin content of milk from a herd of stall-fed cows at all times of the year. The ration contained alfalfa hay of excellent quality, a good ensilage, and a concentrate. The milk was found to be uniform, and a good source of the four vitamins: Fat-soluble A, water-soluble B (or B_1), water-soluble C, and water-soluble G_1 (or B_2).

J. S. H.

New Test for Phenols and Copper.—When the solution of a morphine salt is treated with several drops of hydrogen peroxide and of ammonia water, then stirred with a copper wire, a pink or red color develops, and will reveal the presence of about 1 part of the alkaloid in 3000 of solution. CHARLES C. FULTON (*Am. Jour. of Pharm.*, 1933, CV, 25–29) finds that this reaction is a general one for phenols and their acetyl derivatives, although alcohol must be used as the solvent for many phenols. The pink or red color may soon change to yellow or brown. The test may also be applied for the detection of copper in ores or alloys, or in solution. Morphine will reveal the presence of 1 part of copper in 3,000,000 of solution; thymol, resorcinol, and 4-hydroxy-1, 2-dimethyl benzene will detect 1 part of copper in 1,000,000.

J. S. H.

Priestleyana.—The March, 1933 number of the *Jour. of Chem. Ed.* contains the text of six hitherto unpublished letters of Joseph Priestley with an introduction by Ronald A. Martineau Dixon of Thearne, and an account of the persecution of Priestley by Peter Porcupine contributed by Lyman C. Newell. Other Priestleyana in this number are pictures of the Priestley Museum at Northumberland, Pennsylvania, of places in England associated with Priestley, and of his portrait by Margaret Fitzhugh Browne, as well as reproductions of his bookplates, the frontispieces of his "Experiments and Observations on Different Kinds of Air," the contemporary account of the destruction of his home in Birmingham, and a medal issued on his emigration to "Columbia," the United States.

J. S. H.

VISUAL ACUITY AND SODIUM-VAPOR LIGHT.

BY

M. LUCKIESH AND FRANK K. MOSS,

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In present lighting practice, the spectral character of light is generally of secondary importance in comparison with quantity of light. The exceptions are chiefly those cases of seeing where accurate discrimination of color is necessary. Such a conclusion is justifiable as long as levels of illumination are in general far below the minimum required for really good seeing and the consequent conservation of human resources. Investigations of the influence of spectral quality of light upon seeing have been limited to a study of the relationships between this factor and such functions as visual acuity and speed of vision. However, it is conceivable that contributions from refinements in spectral quality may be of considerable importance when adequate intensities of illumination are widely used and when appraised upon a broad basis of human behavior and welfare. Such quantitative data are not now available.

It has been shown by one of the authors [1] and others [2] that monochromatic light is superior to heterogeneous light when appraised by the criterion of visual acuity. These researches also indicate that monochromatic light near the ends of the visible spectrum is generally inferior to that in the middle region of the spectrum. The superiority of monochromatic light over light of a more extended spectrum

[1] "Monochromatic Light and Visual Acuity," M. Luckiesh, *Electrical World*, **58**, 1911, 450. "The Dependence of Visual Acuity on the Wavelength of Light," M. Luckiesh, *Electrical World*, **58**, 1911, 1252. "The Influence of Spectral Character of Light on the Effectiveness of Illumination," M. Luckiesh, *Trans. I. E. S.*, **7**, 1912, 135.

[2] "Chromatic Aberration and Visual Acuity," Louis Bell, *Electrical World*, **57**, 1911, 1163. "Visual Acuity Related to Intensity and Wavelength," Uhthoff, *Graefe Arch.*, **36–1**, 1890, 33–61. "Ueber die Sehscharfe im farbigen Licht," A. Boltunow, *Zeitsch. f. Sinnes physiol.*, **42**, 1908, 359.

decreases as the brightness-level increases. Obviously, in some cases the gain in the definition or sharpness of retinal images with light of a certain spectral character may be more than counteracted by the distortion of color-values.

Although illuminants now in general use differ somewhat in the spectral character of light radiated, the differences do not appear to be great enough to produce significant differences in visual acuity. It has been shown [3] that this general conclusion may be extended to include light from the mercury arc lamp, at least for a range in brightness from 5 to 125 millilamberts.* However, these statements are not to be interpreted to mean that the quality of light from such illuminants is an unimportant factor in the complete process of seeing, which includes many factors other than visual acuity.

The present paper presents a quantitative comparison of visual acuity under light from an experimental sodium-vapor lamp and a tungsten-filament lamp for a range in brightness from 0.02 to 20 millilamberts. The availability of a sodium-vapor lamp providing a steady, controllable, high-intensity source of monochromatic light enabled the experiment to be conducted under normal seeing conditions. Therefore, the results may be interpreted fairly directly into lighting practice. It is possible that the sodium-vapor lamp may become a practicable illuminant available for special purposes. If its promising high luminous efficiency is eventually realized in actual practice, it may be used in extensive low-intensity lighting fields where color is of little or no importance, such as for country highways and railroad yards.

THE ILLUMINANTS.

Recent developments of the sodium-vapor lamp indicate that this type of lamp has inherent characteristics which suggest its use in certain phases of lighting practice. In the present form, it may be considered as a source of practically monochromatic light since nearly all the visible radiation is of

[3] "Seeing—A Partnership of Lighting and Vision," M. Luckiesh and Frank K. Moss, Williams and Wilkins Co., Baltimore, 1931.

* A brightness of one millilambert is produced, for example, by 1.16 foot-candles on a so-called white surface whose reflection-factor is 80 per cent.

wave-lengths 5890 and 5896 Angstroms, respectively. The luminous efficiency of experimental sodium-vapor lamps is high in comparison with tungsten-filament lamps of corresponding wattages, the lamp used in this research being rated at 2.5 amperes, 12.5 volts and about 35 lumens per watt. Since the lamp is still in the experimental stage, it is difficult to present representative values of luminous efficiency.

It was expedient to use 10-watt tungsten-filament lamps to obtain the heterogeneous light. The lamps operated at approximately normal voltage with a corresponding color-temperature of 2410 degrees K. and a luminous efficiency of 8 lumens per watt.

APPARATUS AND METHODS.

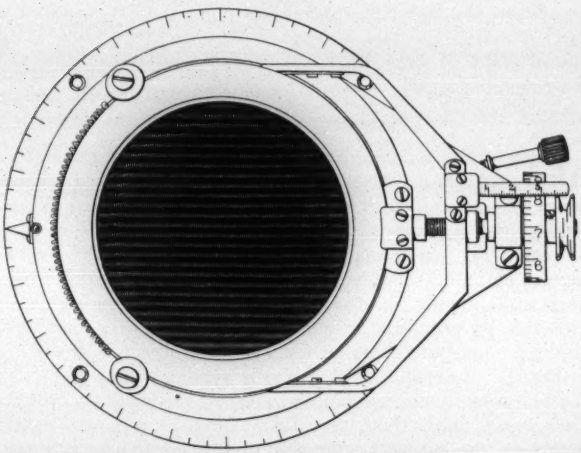
Nine adults possessing normal vision were used throughout the investigation. Each subject sat alone in a darkened room and binocularly viewed a test-object composed of dark bands upon a luminous background from a distance of three meters. The background of the test-object was three centimeters square. The width and separation of the dark horizontal bands of the test-object were simultaneously alterable by adjusting a hand-wheel conveniently located at the right hand of the subject. This test-object is illustrated in Fig. 1. A detailed description is available elsewhere.[4]

The subject was instructed to adjust the separation of the dark bands until they were just visible as separate bands. Although the subjects were not instructed to use any particular method, they invariably approached the threshold condition from a sub-threshold setting of the apparatus. The appearance of the test-object, as the adjustment proceeds from the sub-threshold to the threshold condition, is quite similar to the appearance of a photographic print of a similar pattern during the process of development. As a result, the threshold condition (as appraised by the subject) can be determined with considerable definiteness and confidence. The subjects were not restricted as to time in making a setting of the apparatus; and after a little practice, the settings were made rapidly and easily. This is not the usual experimental

[4] "An Improved Visual Acuity Test-Object," H. E. Ives, *J. O. S. A.*, 1, 1917, 101.

technique in the authors' researches in seeing and was not expected to yield *absolute threshold* values of visual acuity, since subjects seldom if ever concentrate to that extent when free to select their own criteria. The variation in criteria is indicated by the individual values of visual acuity presented in the table. However, the subjects differed only slightly in

FIG. 1.



The test-object [4] consists essentially of two clear glass plates uniformly ruled with parallel opaque lines. The plates are arranged to be rotated in opposite directions about a common axis, thus varying the angular displacement between the two sets of parallel lines. When viewed from a proper distance and against a luminous background, the intersections of the two sets of parallel lines form dark bands. The number of bands and the width of the bands vary as the glass plates are rotated with respect to each other. In this illustration, the number of parallel lines is less than in the actual apparatus for reasons of simplicity and clearness.

the consistency with which they set the apparatus to their own criteria. For the purposes of this investigation, absolute values of visual acuity are not essential nor necessarily desirable from the viewpoint of normal or natural seeing.

The experiment was performed with the eyes dark-adapted for several practical reasons. This method involved the control of a single light-source located behind the test-object and hence has the advantage of simplicity. A more

important reason arises from a possible use of sodium-vapor lamps for the illumination of large areas, such as highways, to a relatively low level of illumination. In this case, the experimental conditions approximate those which may be encountered in practice.

A period of fifteen minutes was allowed for the adaptive processes to reach an approximate state of equilibrium.[5] During this period and throughout the series of visual-acuity measurements, all light excepting that from the test-object itself was excluded. It is obvious from these specifications of the experimental conditions that emphasis was not placed upon obtaining the maximum visual sensitivity by means of complete dark adaptation. Conditions were sought in which the variability of the measurements due to uncontrolled changes in adaptation was minimized.

The brightness of the luminous diffusing background against which the dark bands of the test-object were seen was varied by means of photographic films with relative transmissions of approximately 0.1, 0.01 and 0.001, respectively. While these filters were slightly selective in spectral transmission, this factor is not of importance in this investigation. The brightness of the luminous background was measured directly for each condition by visual photometry and checked at intervals of one week during the investigation. Brightness measurements were also made at frequent intervals during each day by means of a photronic cell permanently mounted and facing the background. This technique insured adequate control of photometric conditions at all times.

At the end of the adaptive period of fifteen minutes a series of measurements of visual acuity was made at each of the four brightness-levels. The sodium-vapor lamp was then replaced by a tungsten-filament lamp, or vice versa, and a period of five minutes allowed for the eyes to adapt themselves to the new conditions before the series of measurements was repeated. This procedure constituted one cycle of the ten cycles of the experiment for each of the nine subjects. The sequence of the four brightnesses presented for each lamp during each cycle, as well as the sequence of the lamps in

[5] "The Nature of Foveal Dark Adaptation," Selig Hecht, *J. Gen. Physiol.*, 4, 1921, 113.

each cycle, was arranged so as to annul any influence of sequence. The results are presented in the accompanying table.

Visual Acuity under Light from Sodium-Vapor and Tungsten-Filament Lamps Expressed as Reciprocals of the Threshold Size in Minutes.

Subject.	Tungsten-Filament. Millilamberts.*				Sodium-Vapor. Millilamberts.*			
	17.6	1.55	0.14	0.023	18.0	2.04	0.17	0.018
1	1.36	1.22	1.03	0.75	1.42	1.31	1.15	0.86
2	1.15	1.06	0.84	0.62	1.27	1.20	1.05	0.75
3	0.39	0.39	0.35	0.29	0.42	0.41	0.39	0.31
4	1.47	1.32	1.17	0.89	1.54	1.42	1.34	1.13
5	0.81	0.69	0.57	0.37	1.01	0.91	0.74	0.49
6	0.72	0.67	0.59	0.49	0.78	0.71	0.65	0.58
7	0.75	0.71	0.65	0.55	0.81	0.76	0.69	0.62
8	1.62	1.40	1.18	0.91	1.69	1.57	1.37	1.05
9	0.88	0.81	0.72	0.58	0.93	0.85	0.78	0.66
Geometric Mean.....	0.94	0.86	0.74	0.57	1.02	0.94	0.85	0.67
Probable Error.....	0.005	0.005	0.005	0.004	0.007	0.006	0.005	0.004

* A millilambert, for example, is the brightness of a diffusing white surface of 80 per cent. reflection-factor receiving 1.16 footcandles. It is also the brightness of a dark gray surface of 8 per cent. reflection-factor receiving 11.6 footcandles.

DISCUSSION.

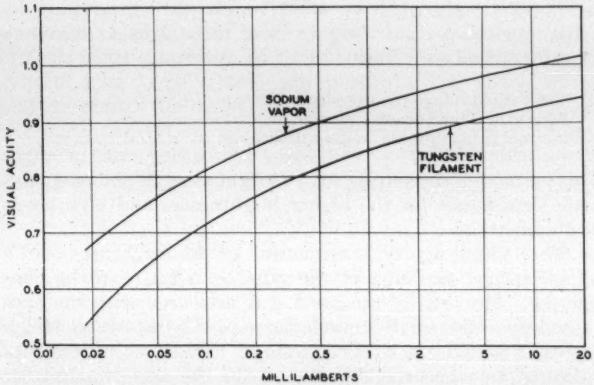
It is evident from these data that light from the sodium-vapor lamp is distinctly superior to that from the tungsten-filament lamp as appraised by the criterion of visual acuity for the brightnesses and type of test-object used. Such a result is to be expected by reason of the elimination or minimization of chromatic aberration in the eye. There are reasons for predicting that such a differential in visual acuity due to differences in spectral quality of light would not be found, if relatively large test-objects of low contrast were used in place of the small high contrast objects. It has been established [6] that the transition from *size* to *brightness-contrast* as the primary factor affecting visibility of colorless

[6] "The Four Variables of the Visual Threshold," P. W. Cobb and Frank K. Moss, JOUR. FRANK. INST., **205**, 1928, 831.

objects occurs for objects which subtend an angle of only a few minutes at the eye.

It will be noted from Fig. 2 that visual acuity is 24 per cent. greater for the monochromatic light at the lowest brightness and 8 per cent. greater at the highest brightness. This difference should become smaller and eventually become

FIG. 2.



The relationship between visual acuity and brightness for light from a sodium-vapor lamp and a tungsten-filament lamp, respectively.

negligible as the brightness is increased. If the differential is expressed in terms of equivalent brightness, it will be noted (Fig. 2) that the monochromatic light is approximately four times as effective as the heterogeneous light at the lower brightness-levels.

In a previous research,[7] the effect on visual acuity of shortening the spectrum at the blue end was determined by the same experimental technique as used in the present work. The results indicated that light from a tungsten-filament lamp, altered in spectral quality by passing it through a concentrated solution of potassium bichromate, is approximately

[7] "The Effect on Visual Acuity of Shortening the Spectrum at the Blue End," M. Luckiesh and Frank K. Moss, *J. O. S. A.*, 10, 1925, 275.

twice as effective as the unfiltered light as appraised by its effect upon visual acuity. At that time the authors concluded that the sacrifice of light, due to filtering out the short-wave visible radiation, is not sufficiently compensated for by the increase in visual acuity for lighting in general, because threshold visibility, as represented by visual acuity, plays only a small part in everyday seeing.

For brightness-levels of the order of one-tenth of a millilambert, the relative effectiveness (as determined by visual acuity) per unit brightness of these light-sources may be summarized as follows:

Unfiltered light from tungsten-filament lamp	1
Filtered light from tungsten-filament lamp	2
Monochromatic light from sodium-vapor lamp	4

This method of comparing the two light-sources obviously has little significance for the higher brightnesses and high levels of illumination.

Since visual acuity is a function of the brightness of the retinal image, the area of the pupil is a factor to be considered. The area of the pupil was measured with the eyes fixated upon the small luminous area of the test-object which was seen amid dark surroundings. These measurements indicated no appreciable difference in the size of pupil for equal brightnesses of the test-object illuminated with monochromatic and heterogeneous light. Hence the difference in visual acuity obtained with these illuminants cannot be attributed to pupillary influence.

At one time or another during the course of the investigation, each of the nine subjects volunteered the information that the test-object appeared more distinct and easier to adjust when illuminated by the sodium-vapor lamp than when illuminated by the tungsten-filament lamp. These subjective data are in agreement with the individual results presented in the table. If it were not for the consistency of the measurements from day to day, as indicated by the small probable errors, it might be argued that the superiority of the monochromatic light may be due largely to an apparent greater definiteness of the lines of the test-object rather than to an actual difference in visibility. However, it is not

reasonable to expect that the apparatus could be adjusted according to a psychological criterion with the degree of exactness attained in these tests.

In previous work [3] on visual acuity under light from mercury-vapor and tungsten-filament lamps at brightnesses between 5 and 125 millilamberts no difference was detected at any given brightness, throughout this range of brightness, even though the object appeared better defined to some subjects when viewed under the mercury-vapor light. Of course, the spectrum of mercury is far from monochromatic; in fact, large quantities of radiation of wave-lengths λ4078 (violet) and λ4358 (blue) are present. The short wave-lengths contribute most to the lack of definition due to chromatic aberration and in this case seem to counteract any degree of monochromaticity attained by the concentration of energy at λ5461 (green) and λ5777 (yellow).

SUMMARY.

It may be concluded that monochromatic light from the sodium-vapor lamp is definitely and significantly superior to the heterogeneous light from the tungsten-filament lamp for revealing detail of small colorless objects at low levels of brightness. In view of the meager knowledge of the influence of spectral quality of light upon *seeing*, this fact appears to be an important one. However, future researches, involving the functioning of the entire human seeing-machine, may prove this to be a factor of minor importance in comparison with other possible effects, either advantageous or deleterious, of light of restricted spectral character. Furthermore, it is well to note that at low levels of brightness and illumination a large part of seeing is accomplished by distinguishing the presence of objects far greater in size than the threshold sizes measured by visual acuity. In other words, much of seeing under low levels of brightness is accomplished by distinguishing brightness-differences rather than minute details. Even though there are extensive fields of low-intensity lighting, such as country highways and railroad yards, where color is of little or no importance, the selectivity of colored objects has much to do with the brightness-contrasts resulting from nearly monochromatic light. Such an illuminant will

decrease many contrasts and will practically obliterate some. An extensive consideration of this matter is necessary before any final conclusion may be drawn as to the desirability of approximately monochromatic light. However, the present paper contains new data on visual acuity which are of scientific and practical interest in an aspect of seeing which will receive more consideration when quantity of light in general use is increased sufficiently above the present primitive levels.

The sodium lamps used in this experiment contained argon gas, but the spectrum of the latter was a negligible factor. Even if the spectrum of argon or neon is quite noticeable in future lamps, it is not likely that the results pertaining to visual acuity will be greatly altered, because of the scarcity of short-wave visible radiation.

PRESERVATION OF PERISHABLE FOODS BY NEW QUICK-FREEZING METHODS.*

BY

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Mechanical refrigeration for the preservation of perishable foods first came into practical use about 1880 in the shipment of meats from Australia to Great Britain. In the United States mechanical refrigeration began to assume practical importance about ten years later. By 1900 the new industry was beginning to become of material importance. Its growth has been greatly accelerated during the past twenty years, and it is no exaggeration to say that now no large urban population in this country could exist for more than a few days without the use of artificially produced cold in the transportation and preservation of its perishable food supply. The refrigeration industry in its various manifestations—including a great many outside of the food industry—is of tremendous size and scope and is one of the most potent factors in our modern civilization.

Nevertheless, ordinary freezing—that is freezing in sharp freezers cooled by uncirculated air—admittedly has many drawbacks and limitations. The extraction of heat, taking place largely by convection, is so slow that considerable damage occurs, with the result that the thawed product is not as good as before it was frozen. Moreover, there is a large number of fruits and vegetables which cannot be satisfactorily preserved by ordinary freezing. Quick-freezing constitutes a very real forward step, and has vastly increased the field for mechanical refrigeration in the preservation of the world's food supply.

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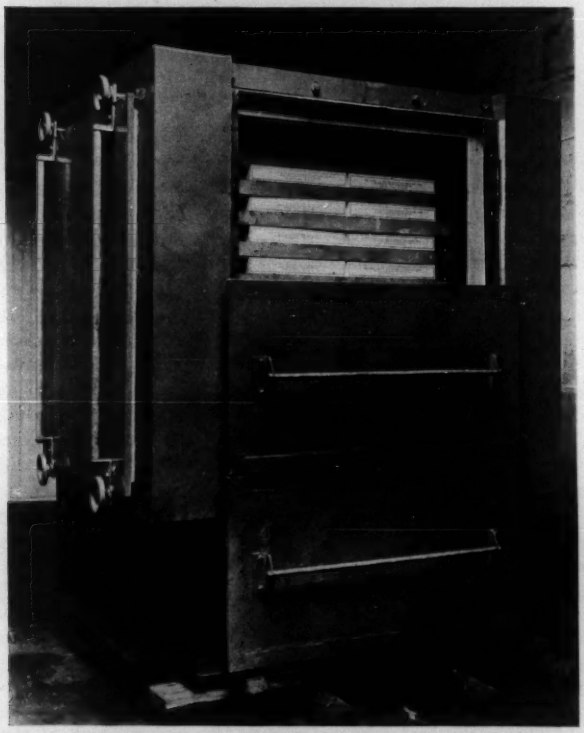
* Presented at a joint meeting of The Franklin Institute and the Philadelphia Chapter of the American Society of Refrigerating Engineers held Wednesday, January 18, 1933.

A DEFINITION OF QUICK-FREEZING.

Quick-freezing, in its narrow sense, is a process of freezing perishable foods very considerably faster than is possible with even the best sharp freezers. Some products require faster



freezing than others; but, generally speaking, the faster the freezing, the better the product. It may be taken as a broad generalization that flesh products should be frozen in from one to three hours, whereas vegetables and fruits may safely be frozen more slowly in from two to six hours.

But the successful commercial development of the new industry requires a much broader interpretation of "quick-freezing." Satisfactory development is possible only when quick-freezing is dealt with as a complete system of getting perishable foods, with inedible waste eliminated at the point of production, from the producer to the consumer in a uniformly excellent condition by means of low temperatures constantly applied. The chain of steps leading from the producer to the consumer involves numerous and intricate problems connected with raw material, pre-freezing treatment, mechanical handling, packaging, freezing, storage, transportation, marketing, and even preparation for the table. Let me point out briefly the scientific problems involved in each of these steps.

RAW MATERIALS.

Quick-freezing will not make a good product from poor raw material; and it must be constantly borne in mind that mere excellence of raw material is not sufficient to ensure a first-class frozen product. Different varieties of the same type of raw material react very differently to the freezing and storing processes, and detailed studies must be made if unfortunate results are to be avoided.

For instance, in the case of seafoods we must first make sure that our raw material is strictly fresh, for in that class of product autolysis produces distasteful changes instead of the beneficial "ripening" which it brings about in meats. One of the main practical difficulties in improving the quality of fish landed by our fleets is the fact that even though the product be kept substantially sterile, autolytic action may render it unfit for food after a comparatively short time. Leakage is another serious problem in frozen seafoods; and even nearly-related kinds of fish may vary materially in the amount of leakage which takes place after the frozen product is thawed. Hake fillets, for instance, leak much more freely than haddock fillets. A "salt-fishy" odor and taste develop more rapidly during storage of cod than of haddock. The development of rancidity, caused by both autolysis and hydrolysis, is much more rapid in fatty fish such as mackerel and salmon than in lean fish like haddock and flounders. Moreover, the same variety of fish caught in the same waters at different times of

the year may vary materially in fat content, and therefore in keeping quality. The digestive enzymes of certain marine organisms are so remarkably strong that the viscera and surrounding abdominal walls are often very quickly broken down when the animal is removed from the water. For instance, mackerel containing "red feed," a minute form of crustacean, are quickly subject to "belly burn" from the destruction of the abdominal walls by digestive enzymes.

Basic problems involved in the use of meats and poultry for quick-freezing have been studied very little, and as yet we have to do a lot of guessing. Very probably, however, the quality of the frozen product is affected both by the breed of animal used and by the method of feeding prior to killing. The flesh and fat of those animals which have fed on feed rich in unsaturated oils are quite probably more likely to become rancid during storage than if the feed has not contained such an element. For instance, practical storage tests have shown that wild sea ducks, which have fed largely on small fish and crustaceans, become rancid in storage more rapidly than domestic ducks which have been finished on cereal feeds.

In the case of fruits it is necessary to consider acidity, vitamin value, color, consistency, and many other factors. Highly acid orange juice, such as that obtained from California navel oranges, is more difficult to store satisfactorily than the milder juice obtained from the Florida valencias. Dr. Fellers, of the Massachusetts State College, has proved that the low-bush blueberries of northern New England are almost destitute of Vitamin C, while the high-bush berries of western Massachusetts are rich in that substance. Different varieties of strawberries and raspberries have vastly different freezing qualities—in fact, even the same variety produced under different climatic and growing conditions may vary materially in its suitability for freezing.

In vegetables, the acceptability of the finished frozen product may depend largely upon such factors as the sugar content and the chlorophylous characteristics of the raw material.

PRE-FREEZING TREATMENTS.

It is essential that perishables be treated correctly before being frozen. Here, as elsewhere, enzyme action is of paramount importance. With seafoods, for instance, aging produces extremely disagreeable odors and tastes. Meats, on the contrary, are rendered much more palatable if they have been properly "aged" or "hung." The process of aging is merely a race between enzymes and micro-organisms, the former causing tendering and the latter various undesirable changes. Successful ripening calls for careful control of time, temperature, humidity, and sanitation.

Different fruits must be variously treated during the period between harvesting and freezing. Preservation of the natural color, flavor, and consistency of strawberries is aided by the addition of sugar syrup, which retards enzyme action, retains the highly volatile flavoring oils, and, by osmosis, penetrates the tissues and thus lessens softening when the product is defrosted. The enzyme actions which cause browning in sliced apples may be so inhibited by treating with a solution of sulphur dioxide and a light salt brine that the frozen product retains its original color for many months.

Blanching—that is, brief scalding—is used with many vegetables to inhibit enzyme action during freezing and cold storage. Unblanched peas quickly lose their original bright green color and take on a very sour or yeasty odor and flavor; and spinach acquires a most unpleasant resemblance to alfalfa hay. Snap beans retain their tenderness better if properly blanched before freezing.

MECHANICAL HANDLING.

In mechanical handling prior to freezing it is necessary constantly to bear in mind that bruising greatly accelerates enzyme action. Bruised fish quickly becomes unfit for food and for this reason there is an increasing tendency to use very finely crushed ice aboard fishing vessels and to handle the fish with extreme care both at sea and ashore. Enzyme action in peas and lima beans is tremendously hastened by bruising such as occurs in mechanical vining, or removal of the peas or beans from the pods.

PACKAGING.

The many problems connected with packaging quick-frozen foods are among the most important and difficult which have had to be met. These problems may be roughly classified as commercial, chemical, and physical.

The commercial part of the packaging problem must be considered from the viewpoints of manufacturing cost, sales, and consumer goodwill. It is essential that the containers be low in first cost, capable of being mechanically set up, filled, closed, and wrapped; possessed of strong sales appeal; and as convenient as possible for use by the several classes of consumers by whom the products will be used. We consider that various types of rectangular paperboard cartons meet these requirements better than any other kind of container. Other organizations, however, prefer to use other types of paper containers, glass, or tin cans.

From the chemical point of view it is of primary importance that the containers minimize enzymic and hydrolytic changes by preventing access of outside air. It is also essential that the materials used in the containers be tasteless, odorless, and non-toxic. For many types of products, such as sugared fruits and fruit juices, the packages must be water-tight. Glass or tin containers capable of maintaining a vacuum or an inert gas atmosphere, have, for certain products, a distinct advantage not possessed by rectangular paperboard cartons.

The principal physical requirement is to minimize desiccation; and this is accomplished by the use of substantially moisture-vapor-proof packaging materials.

FREEZING.

The changes which may take place during the actual freezing operation are many, and none too well understood. Yet they are of basic importance. In this paper it is possible to comment only briefly on some of the more important problems inherent in this phase of frozen food production and distribution.

Ice crystals within the product constitute one problem. When foods are frozen at any speed commercially obtainable there is a progressive separation of fresh-water in the form of

BIRDSEYE
FROSTED FOODS
Red Raspberries
BIRDSEYE
FROSTED FOODS
Mushrooms
BIRDSEYE
FROSTED FOODS
Peas

BIRDSEYE
FROSTED FOODS
Spinach

ice crystals; and the slower the freezing, the larger the individual crystals become. In slow-frozen flesh products, especially such bulky articles as legs of beef and large fish, the individual crystals are frequently so large as to damage seriously the surrounding cell tissue. But in properly quick-frozen foods of either animal or vegetable origin the individual ice crystals are too minute to rupture the cells.

Coagulation of the protein gels and unbalancing of the colloidal structure of the cellular and intercellular fluids is another effect of freezing, whether the process be "quick" or "slow." There is much difference of opinion as to just what causes these changes, but it seems certain that dehydration and crystal formation are at least partially responsible. These phenomena are more pronounced in plant than in animal tissue.

Leakage, or "drip"—the escape of moisture after the frozen product has been thawed—is an important problem in the production of most frozen perishables. The escaping juices carry with them much of the original nutritive value and flavoring content and may result in comparatively dry, tasteless flesh products and flabby, wilted fruits and vegetables. Leakage is caused by a number of factors, among which may be included physical and chemical damage caused by ice crystals, coagulation, dehydration, osmosis, and enzyme action.

Changes in, and redistribution of, the fluid content take place when even small bodies of product are rapidly frozen. These phenomena are greatly increased in the case of such large containers of fluid or semi-fluid products as 400-pound barrels of frozen-packed sugared berries. Such a package requires several days, or even weeks, to become solidly frozen, and during that time many changes take place. The density of the syrup is likely to be very much heavier in the center and lower part of the barrel than in the upper; certain products, such as alcohol, are concentrated near the center of the package; and very large and damaging crystals form. When such fluids as cream are frozen at ordinary commercial speed, the colloidal structure is badly broken; and further coagulation takes place during storage, so that ordinary cold storage cream must be homogenized before it can be used,

and even then is noticeably inferior to the fresh product. Cream can, however, be successfully quick-frozen.

Loss of part of their gas content may take place when certain products are frozen. Sauerkraut, for instance, loses a large part of its carbon dioxide during freezing.

A distinct tendering takes place when meat and poultry are frozen. In the case of beef this amounts to approximately 15 per cent. A further tendering takes place during cold storage.

A substantial reduction in bacterial content results from quick-freezing. Our own investigations have shown that the bacterial content of hamburg steak and raw fish is reduced 60 to 80 per cent. during quick-freezing, and that there is a further substantial reduction during subsequent cold storage. Other investigators have shown that a large reduction in bacterial content results when fruits and vegetables are quick-frozen and cold stored. Apparently the more acid the product, the greater the destruction of bacteria. Quick-freezing, however, causes more damage to some groups of bacteria than to others. No known form of freezing, however rapid, may be counted on for complete sterilization.

STORAGE.

Since the principal value of quick-freezing is to make perishable products substantially imperishable, it is essential that most such products shall remain in perfect condition at commercial storage temperatures for at least nine months or a year. Since at present the lowest available temperatures in most cities are from zero to five above, Fahrenheit, our own holding tests are based on the use of those temperatures. From the chemical and physical points of view, the storage step offers more difficulties than any other phase of low-temperature distribution. Broadly speaking, the principal deleterious changes which may take place during storage are due to enzyme actions, hydrolysis, loss of moisture-vapor, escape of volatile aromas and flavors, absorption of outside odors, and breakage due to improper handling. Of these, the effects of enzyme actions are most varied and difficult to prevent.

Unpleasant off flavors may develop as the result of

enzyme actions during storage. In cold-stored lean seafoods, especially those which have been lightly treated with salt brine to tone up the flavor and lessen leakage, enzyme actions may cause a very decidedly "salt-fishy" odor and taste. In oily fish, such as mackerel and salmon, enzyme actions are very likely to bring about rancidity. In meats also, rancidity of the fatty portions is very likely to develop during storage unless the product has been very carefully packaged. Many different off flavors may be caused in stored vegetables. For instance, peas in which the enzymes have not been inactivated acquire a very decided "yeasty" odor and taste. Unblanched spinach develops an alfalfa-like flavor. Enzyme actions frequently cause undesirable changes in the flavor of cold-stored fruits and fruit juices. For instance, raspberries are very likely to become extremely acid after prolonged cold storage. Orange juice may develop a distinct off flavor similar to that which occurs very rapidly in the freshly extracted unfrozen juice.

Color changes may result from enzyme actions in frozen perishables. Seafoods may become yellow; meats assume an unnatural dark brown color; and fruits lose their natural bloom and acquire an unappetizing washed-out appearance.

The consistency of products may be favorably or adversely affected by enzyme actions during prolonged storage. Fish "hamburg"—i.e., comminuted raw fish assembled into steaks, blocks, or other forms—to which a slight amount of salt has been added for flavoring and to cause cohesion of the individual pieces, may become so increasingly tough during storage that eventually it may assume a rubber-like consistency. Meats and poultry, on the other hand, become progressively more tender during storage.

Undesirable changes during cold storage may be altogether prevented or largely minimized by proper treatment and packaging before freezing. Deleterious enzyme actions may be completely prevented in many vegetables by blanching or scalding before freezing. In certain fruits such action may be largely inhibited by the addition of sugar before freezing. Emulsions may be stabilized by the addition of certain gums and other binders. Oxidative changes in liquids may be greatly slowed up by efficient deæration before freezing.

Pre-freezing treatments with such chemicals as sulphur dioxide and ordinary salt brines are effective in preventing "browning" in sliced apples. The use of vacua and inert gases may be very helpful.

In the prevention of the various changes which may take place in storage, proper packaging is essential. For numerous reasons it is highly desirable that the product be packaged before rather than after being frozen; and that the packages themselves be substantially moisture-vapor-proof and air-tight.

TRANSPORTATION AND MARKETING.

Chemical and physical problems arising during transportation and retailing are very similar to those encountered during cold storage. If the products have been so treated and packaged that they will withstand prolonged storage, they may also be safely transported and retailed provided they are kept at low, even temperatures in the neighborhood of five degrees Fahrenheit. In the early days of quick-freezing, much spoilage resulted from too high temperatures during transportation and from actual thawing and subsequent spoilage during retailing. These sources of trouble, however, have now been almost entirely overcome by the use of improved refrigerator cars and by retailing quick-frozen products through only those outlets equipped with mechanically cooled storage cases capable of maintaining the desired temperatures.

IN THE HOME.

Quick-frozen perishables may be kept in any good refrigerator, the length of time for which they can be satisfactorily held depending upon the temperatures available. The lower the temperature, the better the products will keep. Generally speaking, it is true that quick-frozen fish, poultry, and meats will keep longer at a given refrigerator temperature than similar fresh products will. That is true simply because the quick-frozen products, having been sanitarily handled and frozen soon after they were killed, have a very low bacterial content as compared with similar fresh foods as ordinarily available. On the other hand, most quick-frozen fruits and vegetables, having been more seriously affected by freezing, do not keep as long after being thawed.

Generally speaking, the cooking of quick-frozen foods offers comparatively few new problems. Standard cooking methods may be used. Practically all quick-frozen foods may be put on to cook either while still solidly frozen or after they have been thawed. Thawed quick-frozen meats and seafoods require about the same amount of cooking as similar products which have not been frozen; but if the products are put on to cook while still frozen a slightly longer cooking time is required. Quick-frozen vegetables require only from one-half to one-third as much cooking as fresh vegetables; and this fact is of considerable aid in retaining color, flavor, and vitamin potency in the cooked product.

HEALTH VALUES.

Quick-freezing does more than make possible the economical distribution of perishable foods "as good as fresh." When the intrinsic economies of the new system are utilized fully, quick-frozen foods are actually better than "fresh" foods distributed unfrozen by present methods. This is so because quick-frozen perishables are preserved at the height of their goodness, are sanitarily packaged, and are protected against deterioration throughout the storage and distribution processes.

Under present conditions the vast majority of all perishable foods are consumed from two to thirty days after being killed or harvested. Most of them are transported hundreds of miles and pass through several hands before reaching the consumer. Yet these products are quite readily perishable and deterioration begins the moment the animals are killed, the fish caught, or the plants harvested. The best fish is fresh fish—for both bacterial growth and enzyme actions combine to produce undesirable odors and flavors and unhealthful chemical changes such as oxidation of fats. Aged meat is more tender and juicy than that which has been fresh killed; but the aging process is a race between bacteria, molds, oxidation, and enzyme actions, and by our present methods of distributing unfrozen meats the forces of deterioration frequently predominate. Peas and corn begin to lose their sugar content immediately after harvesting, asparagus loses its original tenderness, and spinach wilts and spoils. Most

fruits must be picked under-ripe; and, while they ripen during the distribution process, there are almost always more or less undesirable changes before the fruits are consumed.

Quick-frozen products, on the other hand, may always be preserved at the very height of their goodness, and if properly packaged and distributed, should reach the consumer with all their intrinsic excellencies intact. There need be little, if any, desiccation, multiplication of organisms, oxidation, loss of vitamin values, or escape of volatile aromas and flavoring elements. Quick-frozen packaged fish fillets should reach the consumer with a bacterial content of not more than fifty thousand per gram. Similar products distributed unfrozen are likely to contain from ten to twenty times as many bacteria. In a recent test carried out at the Massachusetts Institute of Technology, quick-frozen hamburg steak was found to contain only about one-fifth as many bacteria per gram as the best quality of freshly ground hamburg obtainable in first-class stores; and if the comparison had been with ready-ground hamburg as purchased in the average cheap retail store, the comparison would certainly have been even more favorable for the quick-frozen product.

Quick-frozen vegetables, after being cooked, have a better color and probably a higher vitamin content than similar cooked fresh vegetables. This is true because the amount of cooking required for fresh vegetables is usually sufficient to lessen the brilliancy of color and destroy a large part of the original vitamin potency, while quick-frozen vegetables, requiring only about half the cooking time, are a brilliant green color and rich in vitamins.

COSTS.

Inasmuch as it is not the purpose of this talk to deal with the commercial side of the quick-frozen foods problem, I wish to point out only that, because of the numerous economies involved, quick-frozen foods can be distributed from the producer to the consumer more cheaply than is possible by present methods of handling the products fresh. These remarkably low costs have been made possible by the application of our knowledge concerning the basic scientific facts underlying economical methods of harvesting, manufacturing, packaging, and transporting quick-frozen foods. Suffice it to say here that the frozen foods of the near future will be not

only better and more convenient than similar unfrozen fresh foods, but will involve less spread between producer and consumer.

RESEARCH AND THE FUTURE OF QUICK-FREEZING.

Three-quarters of the world's food supply may be classed as perishable. Ultimately a large proportion of this vast bulk of foods will be distributed by means of quick-freezing. The new methods make perishables substantially imperishable, and eliminate time and space except as financial factors. Perishable foods may be produced anywhere in the world where they can be grown to the best advantage, and may be consumed anywhere and at any time that they are required. The perishable food problem of the future will therefore be increasingly international in scope, and will necessarily involve many changes in international policy and good will.

It is almost literally true that no two quick-frozen food products are produced by exactly the same methods; and it is perfectly obvious that scientific research will have to play a leading rôle in the further development of this new industry, which promises to rival in scope even such giant industries as those of transportation and communication. The problems involved will probably continue to be largely of a chemical nature, but those of bacteriology and physics will be of scarcely less importance.

The refrigeration industry is certain to be greatly affected by the requirements of quick-freezing. Less bulky, high-speed refrigerating apparatus will be developed. Lower storage temperatures will come into general use; and these low temperatures will be available in every good-sized community throughout the civilized world. Refrigerated transportation on land and sea will be greatly expanded, and the temperatures employed will be lower than those at present available. Low temperature refrigeration equipment for wholesale warehouses and retail outlets will come into general use. Proper low-temperature storage facilities will be standard equipment in hotels, restaurants, institutions, and most private homes.

In short, I believe that quick-freezing will offer one of the largest single fields for the scientific research of the future.

THE STRUCTURE OF UNIMOLECULAR FILMS.

I. SURFACE POTENTIALS OF FILMS OF LONG CHAIN COMPOUNDS.

BY

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The examination of the structure of surface films by the surface potential method has been shown by Schulman and Rideal [1] to give more complete information than ordinarily obtainable from force-area data. Any method which permits one to study the influence of film structure on the kinetics and type of a reaction occurring at an interface would be valuable to the biochemist. The present investigation was undertaken to test the method of surface potentials and to obtain preliminary information on the structure of surface films of stearolactone.

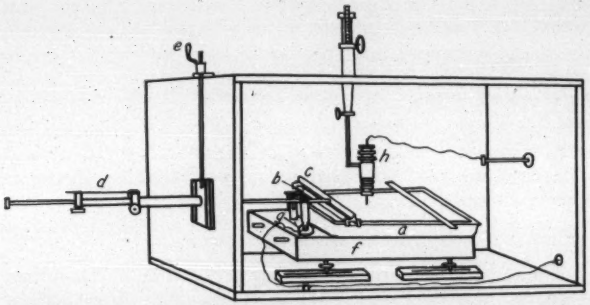
THE EXPERIMENTAL METHOD.

The method employed for the determination of the surface potentials was essentially the same as that described by Schulman and Rideal but with several modifications. The assembled apparatus is shown in Fig. 1. A pyrex glass vessel (*a*) 26 cm. × 21 cm. × 2.5 cm. dimensions, with carefully ground and polished edges, served as a trough. To vary the area occupied by the film placed upon the surface, the glass slide (*b*) held in position by the guide (*c*) was moved by means of a rack and pinion arrangement (*d*) to which was attached a metal scale for noting the extent of the movement. By providing the slide carrier with a vertical adjustment (*e*) it was possible to push a number of glass slides across the trough to obtain a clean surface without danger of contamination. The trough was supported by a heavy copper thermostat (*f*) which maintained the liquid in the vessel at a constant temperature. For the purpose of providing the thermostat with

[1] *Proc. Roy. Soc.*, A, 130, 259, 270, 294 (1931).

a horizontal adjustment it was mounted on three metal bars, two of which were grooved to accommodate the levelling screws. One electrode consisted of a calomel cell (*g*) which made contact with the liquid in the trough by means of a bridge and a fine siphon. By moving the air electrode (*h*) through an arc parallel to the surface it was possible to test the uniformity of the film. Suitable insulation for the electrode and the lead to the electrometer was provided by the use of amber. In order to reduce the resistance of the gas space, polonium (Radium F) was deposited electrolytically on

FIG. 1.



Sketch of apparatus for measurement of surface potentials. The symbols are explained in the text.

the electrode from a radioactive solution containing radium *D*, *E*, and *F*, and under the conditions of plating some radium *D* was probably deposited along with polonium.

The potentials were obtained by a null method with the use of a Swann-type electrometer having a sensitivity of 3 mm./mv. at 1 meter distance. Both the surface potential apparatus and the electrometer were mounted on stable concrete supports to reduce vibration effects to a minimum.

Paraffin wax (m.p. 68–71°) recrystallized from *n*-hexane was used in covering the slides and the trough. The buffer solutions were prepared according to Clark by dissolving c.p. chemicals in triple-distilled, grease-free water, great care being taken to prevent contamination by dust of the atmos-

phere. The palmitic acid was recrystallized four or five times from alcohol; the myristic acid was purified by recrystallization from petrol ether (b.p. 40–60°). Stearolactone was prepared according to the method described by Clutterbuck [2] and recrystallized a number of times from methyl alcohol. Stock solutions were prepared by dissolving the compounds in carefully redistilled *n*-hexane (b.p. 65.5–66.0°). Instead of the usual calibrated dropping pipette or cumbersome micropipette a Burroughs and Wellcome 'Agla' micrometer syringe was used in dropping the required amount of solution on the liquid surface. Force-area measurements carried out on the palmitic and myristic acid solutions not only proved the purity of the preparations but also indicated that several hundredths of a cubic centimeter of solution could be delivered with an accuracy of 2 per cent.

MYRISTIC AND PALMITIC ACIDS.

In Figs. 2 and 3 are plotted the values of ΔV as ordinate, the mean molecular areas as abscissa, for a film obtained by spreading myristic acid from *n*-hexane. The number of molecules per square centimeter was varied by compressing the film in the usual manner after successive additions of acid.

For molecular areas greater than 85 Å^2. it was necessary to allow approximately two hours to elapse after spreading before a homogeneous film was obtained. It appeared that the rather rapid evaporation of the solvent left a large part of the acid in the condensed state, subsequent spreading requiring almost 2 hours' time. On rapid compression of the film to areas below 35 Å^2. and potentials above 215 mv. a metastable curve Fig. 2 *b*. was obtained. After allowing approximately seven or eight minutes to elapse the potential fell to a constant value in which curve Fig. 2 *a*. was obtained on expansion. From the curves it is seen that definite transition points occur at molecular areas of 39, 54, and 85 Å^2. with a rather less well-defined one between 27 and 30 Å^2.

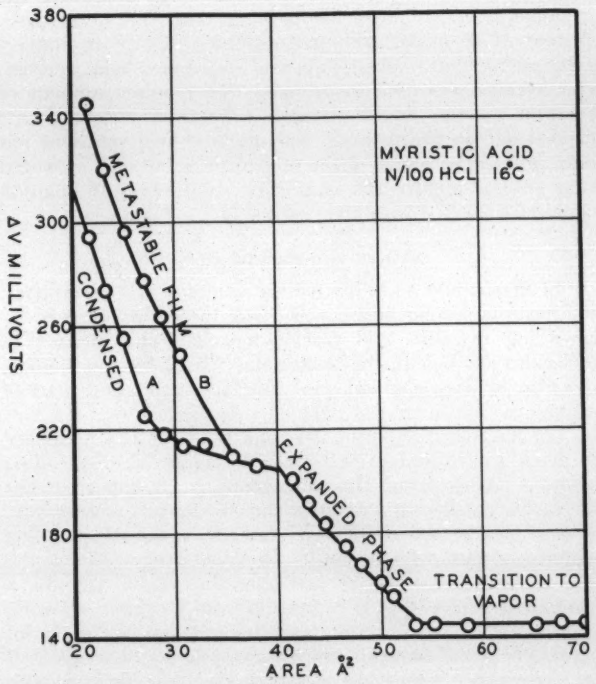
Over the liquid condensed and expanded regions the inter-

[2] *J. Chem. Soc.*, **125**, 2330 (1924).

facial potential difference varied proportionally with the number of molecules per square centimeter.

The immersed "head groups" or dipoles of the molecules comprising the surface film approximate a Helmholtz double

FIG. 2.



Curve showing the variation in surface potential of a film of myristic acid in the transition from the condensed state to the pre-homalic phase.

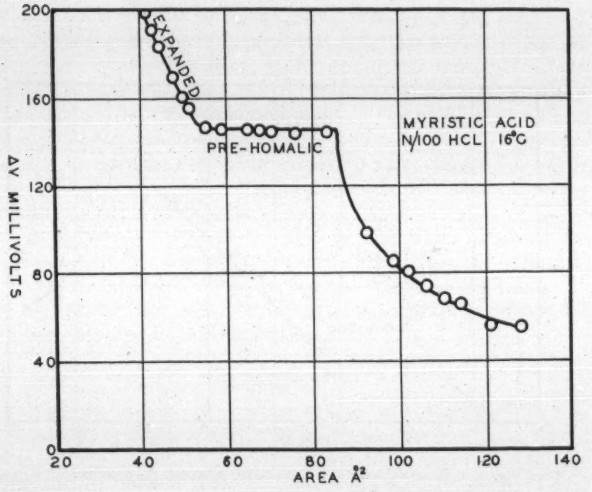
layer and accordingly the interfacial potential can be expressed by the equation

$$\Delta V = 4\pi n\mu, \qquad (1)$$

where ΔV is the difference of potential caused by n molecules per square centimeter of film forming material and μ the apparent vertical component of the molecular electric moment.

Within the limits of existence of a given phase one may obtain a true value of the molecular electric moment, $\bar{\mu}$, from the slope of the linear ΔVvn curve which, on extrapolation to

FIG. 3.



The change in surface potential involved in the transition from the expanded to the vapor homalic) phase.

$n = 0$, generally does not pass through the origin. Thus the expression relating μ and $\bar{\mu}$ may be given by

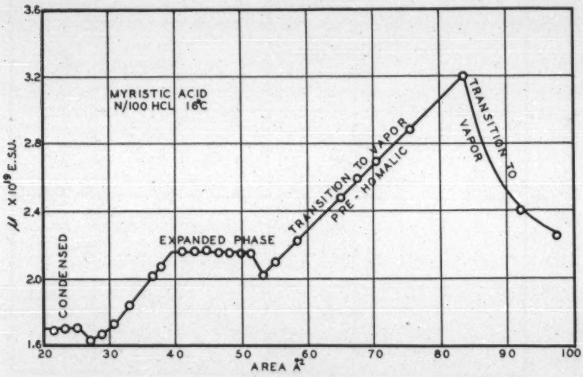
$$\bar{\mu} = \mu - \frac{\Delta V \mu}{4\pi u}, \qquad (2)$$

where $\Delta V\mu$ is the change in the zero potential caused by the film. It is seen that the contribution of the second term of equation (2) will be either positive or negative, depending

on the relative distribution of ions beneath the surface layer after deposition of the film. Schulman and Hughes * have recently studied the nature of the ion layer and found, in general, with which our data are in agreement (see Tables I and II), the contribution of the second term to be positive for condensed films and negative for the expanded state. In many instances it would be necessary to evaluate μ and $\bar{\mu}$ in order to obtain information concerning the change in the ion layer beneath the film.

From Fig. 4, in which the values of the electric moment

FIG. 4.



The alteration in the vertical component of the electric moment in the transition of a myristic acid molecule from the condensed to the vapor phase.

were obtained upon application of the equation $\Delta V = 4\pi n\mu$, it is seen that the value of μ is smallest in the liquid condensed state, which is in agreement with the freely tilted molecular structure described by Lyons and Rideal.[3]

It is reasonable to assume that the constant value of ΔV and the simultaneous increase in the value of μ from 2.05 to 3.20 $\times$ 10^{-19} e.s.u. found on expansion of the expanded

* Private communication.

[3] *Proc. Roy. Soc.*, A, 124, 323 (1929).

phase from 54 Å². to 85 Å². was due to a compensatory rotation of the polar group. The fall in ΔV and likewise in the electric moment at 85 Å². may be accounted for by the assumption that the available area per molecule was just sufficient to permit the molecule to acquire the horizontal position assumed for the vapor state.

Although these results apparently confirm, as observed by Schulman and Rideal[1], the existence of a pre-homalic phase some doubt of this interpretation may exist in view of a recent investigation of this region by Schulman and Hughes.* On exploring the surface potential near the trough edges on expansion of the film from 55 Å². to greater molecular areas evidence was obtained of a pseudo-equilibrium existing between vapor and expanded films. The failure to note a similar phenomenon in our experiments may not, however, be due to the film not being examined near the trough edges but to the use of *n*-hexane as a solvent in place of petrol ether.

A summary and comparison of the data obtained on films of palmitic and myristic acids with the data obtained by Schulman and Rideal are given in the following table.

A satisfactory agreement appears to exist between the values obtained in both investigations.

STEAROLACTONE.

The behavior of surface films of stearolactone (γ-tetradecyl butyrolactone) was examined, for not only would the surface structure of a γ-lactone be of interest, but the ring can be opened through either oxidation to the keto acid or hydrolysis to the hydroxy acid. It is hoped that data obtained by the surface potential method on the above reactions will be of value in a future investigation involving certain γ-glucose derivatives.

Stearolactone, like palmitic acid, was found to give a stable liquid condensed film on a citrate buffer pH 6.4. The surface pressures of the films were measured with an Adam type of trough having a sensitivity of 0.3 dyne per degree. On extrapolation of the force-area curve to zero pressure the

* Private communication.

TABLE I.

$t = 16°$ C.

Acid.	State.	Molecular Area in Å².	ΔV Millivolts.		Mean Electric Moment $\mu \times 10^{18}$ e.s.u.	
			Obs.	S. & R.	Obs.	S. & R.
Myristic on N/100 HCl.....	Liquid condensed	25–20.6	256–306	—	1.70 ($\bar{\mu}$ = 1.58)	$\bar{\mu}$ = 1.56
	Transition	25–39	215	219	1.60–2.16	1.47–2.29
	Expanded	39–54	147–215	154–219	2.17 ($\bar{\mu}$ = 2.50)	2.29 ($\bar{\mu}$ = 2.50)
	Prehomalic	54–85	147	154	2.17–3.25	2.29–3.6
	Homalic	120	56	40	1.75	1.2
Palmitic on citrate pH 6.4.....	Liquid condensed	—	—	—	1.72 ($\bar{\mu}$ = 1.58)	1.71 ($\bar{\mu}$ = 1.59)

limiting molecular area was found to be 31 Å². The force-area curve was similar to that obtained for iso-oleic acid on N/100 HCl in which the end group is CH : CH.COOH and the limiting area 28.7 Å².[4] If one assumes the area per molecule to increase 2 Å². for each additional CH_2 head group then the limiting area occupied by the lactone ring would be 25 + 6 = 31 Å²., the value found experimentally.

TABLE II.

Stearolactone.

t = 16°. On Citrate Buffer pH 6.4.

State of Film.	Mean $\mu \times 10^{19}$ e.s.u.	$\bar{\mu} \times 10^{19}$ e.s.u.	ΔV_μ Millivolts.
Liquid condensed.....	4.62	4.55	+ 15

As a linear force-area curve and a constant value of $\bar{\mu}$ were obtained on compression of the film to a molecular area of 23 Å². it may be assumed that not only the direction of the electric moment remained unchanged but two of the relatively non-polar CH_2 groups of the lactone ring were pushed out of the surface by rotation about their C—C linkages.

If the above assumption is valid then the rather large value found for the vertical component of the molecular electric moment may be ascribed to the $-\overset{|}{\underset{|}{C}}-O-\overset{|}{\underset{|}{C}}-$ linkage as the chief source of potential of the film (ΔV_μ = + 15 mv.) was the dipole $-\overset{|}{\underset{|}{C}}-O-C^- = 0$.

[4] Adam, N. K., "The Physics and Chemistry of Surfaces," Clarendon Press, Oxford (1930).

Atomic Weight of Cesium.—G. P. BAXTER AND J. S. THOMAS (*Jour. Am. Chem. Soc.*, 1933, LV, 858–859) have determined the ratio between cesium chloride and silver, and thereby obtained a value of 132.91 for the atomic weight of cesium.

J. S. H.

Fatty Acids of Potato Starch.—LEO LEHRMAN AND ELVIN KABAT (*Jour. Am. Chem. Soc.*, 1933, LV, 850) determined the preformed petroleum ether extract of potato starch, and found 0.02 per cent. They then hydrolyzed a large sample (2 kilograms) of the starch, determined the fat content of the hydrolyzed mass, and found approximately 0.02 per cent. Therefore fatty acids are not contained in the molecule of potato starch.

J. S. H.

International Atomic Weights for 1933.—The annual report of the Committee on Atomic Weights of the International Union of Chemistry (*Jour. Am. Chem. Soc.*, 1933, LV, 441–452) recommends only two changes. The new value for the atomic weight of iodine is 126.92, the new value for the atomic weight of lanthanum 138.92.

J. S. H.

Melting Point of Acetylsalicylic Acid.—GEORGE D. BEAL AND CHESTER R. SZALKOWSKI (*Jour. Am. Pharm. Asso.*, 1933, XXII, 36–40) have made a study of the factors which influence the melting point of acetylsalicylic acid. They recommend that the acid be crushed to a number 100 powder, then dried in a desiccator over sulphuric acid for 12 hours. This powder is then placed in a tube, which is sealed at one end and has an internal diameter of 0.8 to 1.0 millimeter, to form a column 2.5 to 3.0 centimeters high. The tube is inserted in a bath which has a temperature of 130° C. Heat is applied so that the temperature is increased 3° C. per minute, until the sample melts and becomes clear throughout. Under these conditions, acetylsalicylic acid has a melting point not below 135° C. If the acid be crushed still finer, a slight portion may be decomposed during trituration. The acid melts with decomposition, and a portion of this decomposition occurs during melting. The products of decomposition and the unaltered acid form an eutectic; and the melting point is depressed. Acetic acid is evolved during melting. The quantitative saponification procedure demonstrates that acetylsalicylic acid, which has been melted and then permitted to solidify, is less pure than the original sample.

J. S. H.

THE VARIATION OF SECONDARY EMISSION WITH HEAT TREATMENT.*

BY

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ABSTRACT.

The ratio of the number of electrons striking a surface to the number leaving it was determined under various conditions for a number of metals contaminated by the condensation of grease vapors on them. The curves showing the variation of secondary emission with incident electron energy (evidently characteristic of the contamination rather than of the metals) are similar for all the targets and resemble the results obtained by Gehrts. Reducing the amount of the contamination by heating the metals at first reduces the secondary emission until it falls below that expected from a clean metal. The emission then increases with further heating and the characteristics of the metal appear. The variation of the work function during the "outgassing" process is indicated by this increase of the secondary emission followed by a decrease of the secondary emission as the process continues.

The emission of electrons by a metal bombarded with electrons has been investigated by a number of observers.[1–8] The earliest of this work showed that in addition to reflected incident electrons, there must be others leaving the bombarded metal as a result of ionization, for, under suitable circumstances, more electrons leave the metal than strike it. The

* Part of a thesis submitted to the Physics Department of the State University of Iowa in partial fulfilment of the requirements for the degree Doctor of Philosophy.

[1] O. von Baeyer, *Deutsch Phys. Gesell. Verh.*, **10**: 24, p. 953 (1908); *Phys. Zeitschr.*, **10**: 176 (1909); *Ber. d. D. Phys. Ges.*, **10**: 96 (1910).

[2] Gehrts, *Ann. d. Phys.*, **36**: 995 (1911).

[3] N. R. Campbell, *Phil. Mag.*, **22**: 276 (1911); **24**: 527 (1912); **25**: 803 (1913); **28**: 286 (1914); **29**: 369 (1915).

[4] A. W. Hull, *Phys. Rev.*, **7**: 1 (1916).

[5] McAllister, *Phys. Rev.*, **21**: 122 (1923).

[6] H. E. Farnsworth, *Phys. Rev.*, **20**: 358 (1922); **25**: 41 (1925).

[7] Petry, *Phys. Rev.*, **26**: 346 (1925); **28**: 362 (1926).

[8] Hyatt and Smith, *Phys. Rev.*, **32**: 929 (1928).

experiments of Davisson and Germer [9] have brought into prominence the reflection of electrons without energy loss. These "reflected" electrons, however, constitute but a small fraction of the total emission of electrons when metals are bombarded with electrons of high energy. The processes involved in the emission of the slower "secondary electrons" are not so well understood. In fact, although there has been general qualitative agreement among various observers concerning the more pronounced effects, the results have not agreed quantitatively. This has been due in part to the inherent difficulty of measuring the magnitude of an ionization effect, and in part to the marked dependence of this effect on the slightest contamination of the surface.

Previously the writer,[10] using secondary emission of electrons as a tool, examined a number of the spurious effects arising from the contamination of surfaces by the condensation of vapors. Experiments performed with the apparatus (designed to give fields) previously described indicated that the amount of the secondary emission caused by electrons of energies between 30 and 300 volts was very much increased by the presence of the contamination. The results, however, could not be interpreted quantitatively; hence it was decided to construct apparatus in which the ratio of the total secondary emission to the primary current could be measured accurately.

APPARATUS.

Figure 1 shows a schematic diagram of the apparatus including electrical connections. The source of electrons is a short tungsten filament, *F*. A beam of electrons from the filament is defined by the first of the circular diaphragms, *D*. The beam is then incident on the target, *T*, and the net current to the target is measured by the galvanometer, *G* (when switch, *X*, is thrown to the right). To measure the total incident current, the target is pulled aside, so that the electrons pass into the Faraday cylinder, *C*. The current to the cylinder, its diaphragm, and the diaphragm of the pair *D* facing the cylinder (obtained by throwing *X* left) is taken as a measure of the number of incident electrons.

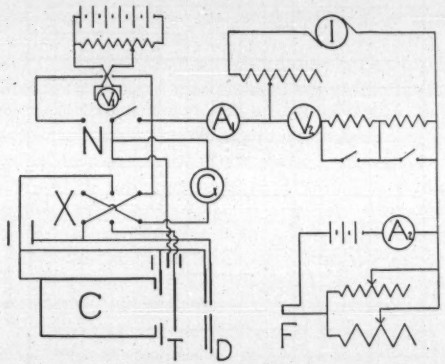
[9] Davisson and Germer, *Phys. Rev.*, **30**: 705 (1927).

[10] Paul L. Copeland, *Phys. Rev.*, **35**: 982 (1930).

The primary beam may be given any desired energy up to 3,000 volts (as indicated on V_2) by means of the generator, I, and the adjusting resistance. The target may be set at various potentials (indicated on V_1) relative to its surroundings by the potential divider and switch arrangement. A separate filament (not shown) was provided for heating the targets by electron bombardment.

Preliminary experiments indicated that C (for the conditions under which it was used) was almost perfectly absorbing; that the electron beam was nearly homogeneous in energy; and

FIG. 1.



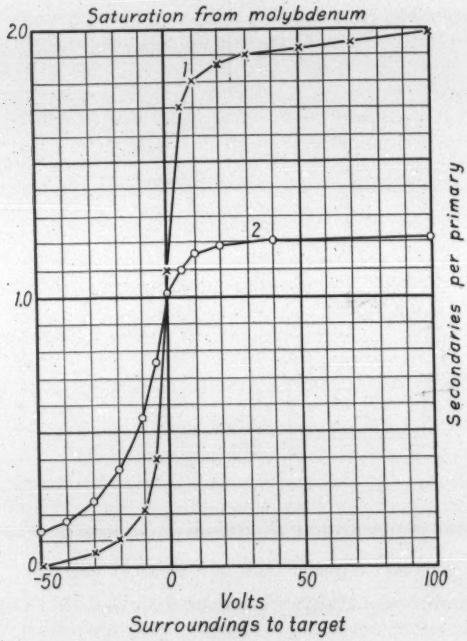
that there was very little spreading of the electron beam beyond the diaphragm at D, intended to define it.

SECONDARY EMISSION FROM CONTAMINATED SURFACES.

A number of metals were mounted so that they could be used one after another as targets. Contamination of the target surfaces was assured by liberating in the tube a slight pressure of oil vapor by warming a side tube containing a small quantity of Polarine and soft wax. The vapor was frozen out by liquid air before the observations were made, but a part, which had condensed on the surfaces, remained to produce an observable effect.

In previous work [10] with filaments, it was shown that while contaminated surfaces needed strong fields in a direction to aid the escape of electrons to produce saturation of the secondary currents, it appeared that this was not the case for clean metals. While it was not possible to produce such intense fields about the flat plates used as targets in the present appa-

FIG. 2.



ratus, experiments similar to the former were tried. Fig. 2 gives characteristic results. To obtain these curves, T was maintained 300 volts positive with respect to the source, F, so that the electrons striking the target had at all times the same velocity of impact. The potential of the surroundings

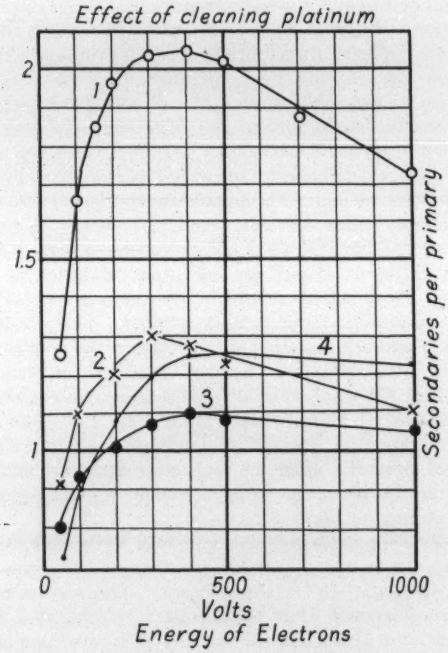
of the molybdenum target was varied. The ordinates of these curves show the number of electrons leaving the target for each incident electron. The abscissas give the potential of D relative to T; to the left of the origin the applied field retards the escaping electrons, while to the right it aids their escape. Curve 1 was taken before the target had been cleaned by heating; curve 2 was obtained after the target had been raised to a bright red heat for several minutes.

The shape of the curves to the left of the origin indicates roughly the velocity distribution of the secondary electrons; the curves rise rapidly near the axis, because slow speed secondaries are especially abundant. The shape of both curves for accelerating fields (just to the right of the origin) is suggestive of the form of the curves obtained formerly for contaminated targets only and interpreted as indicating fields due to the contamination. The smaller secondary current with the lower field values for these curves, however, is probably not due to the applied field compensating a strong surface field, but rather to elastically reflected primaries liberating secondaries at D which return to T unless a potential difference sufficient to stop them is applied. For accelerating fields the secondary emission is larger from the contaminated surface, and the slope of the curves at the extreme right suggests that the applied field is increasing the current from the contaminated surface more than from the clean. This may be an effect of the surface fields arising from the contamination, but the evidence is less pronounced than that obtained in the work on wires to which much larger fields could be applied easily.

The variation of secondary emission with energy of the incident electrons was observed for six different metals which had been subjected to the same vapor. The results were so very nearly identical that they must be dominated by the contamination rather than the metal. A typical one of these curves is shown in Fig. 3, for which platinum happened to be the base. In this figure the ordinates (as before) represent the number of secondaries per primary electron. The abscissas of this figure, however, represent the potential of the target relative to the source, and hence measure the energy of the incident electrons. For each observation the surround-

ings of the target were made positive with respect to the target by one tenth the potential difference between the target and source. Curve 1 shows the results due to the contamination. Even for electrons of 50 volts energy (the lowest used) more than one electron leaves the target for each one which

FIG. 3.



strikes. The secondary current at first increases rapidly with energy of incidence and reaches a rather broad maximum at about 300 volts, after which it declines rather rapidly. In most of the early work upon secondary emission when the influence of surface contamination was not appreciated, the

metals were not heated in vacuum and the curves obtained [2] were similar to curve 1 and were probably due to accidental contamination by grease.

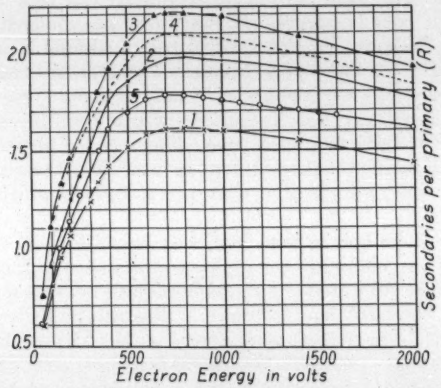
The subjection of the targets to heat treatment at first reduced the secondary emission. Curve 2 was obtained after the target had been raised for a short time to just below red heat. In this curve the position of the maximum and the slope beyond the maximum are not radically altered. Raising the target to red heat put the surface in condition to give curve 3. The form of this curve is quite different from the first two. The position of the maximum has changed and the slope of the curve to the right of the maximum is much diminished. The curves for the various targets differ more than previously, and the metals evidently influence the results. Curves of this type, however, are peculiar in that the secondary emission is reduced below that observed for clean metals. After still further heat treatment curve 4 was obtained, and it is quite similar to 3 save that the secondary emission has increased.

After the whole system had been baked for several hours at 450° C. to eliminate the grease contamination, the various targets were subjected to still more rigorous heat treatment by electron bombardment. Figure 4 illustrates the results for platinum. The curves are numbered in the order in which they were obtained. The heat treatment preceding each successive curve was made increasingly severe, and holes were melted in parts of the platinum target just before curve 5 was taken. This variation of the secondary emission is somewhat similar to that observed in thermionic emission [11] where heating filaments to one temperature causes impurities to diffuse to the surface and decrease the work function, while heating to higher temperatures serves to remove the impurities and increase the work function. Whether or not such a process occurs here, the observed variation of the secondary emission would be expected. The secondary emission is probably influenced both by the variation of the work function and by the simplification of the crystal structure in the heat treatment. The effect of crystal simplicity on secondary emission

[11] Langmuir, *Gen. El. Rev.*, **23**: 503 (1920).

was observed by Rao [12] who found that the secondary emission from a single crystal of nickel was much less than that from polycrystalline nickel. The variation of the work function during heat treatment has frequently been verified in studies on the photo-electric effect. DuBridge [13] found a stage in the outgassing of platinum in which the photo-electric current first increased and then decreased, and a number of investigations [14]

FIG. 4.



have shown that the work function decreases and then increases in the course of the outgassing process for different metals. The curves of Fig. 4, then, may be interpreted as showing how the secondary current varies with the work function during the heat treatment.

SUMMARY.

With grease contamination on the targets, the secondary emission is high, reaching a maximum of about two secondaries

[12] S. R. Rao, *Roy. Soc. Proc.*, **128**: 41 (1930).

[13] L. A. DuBridge, *Phys. Rev.*, **29**: 461.

[14] For example see L. W. Morris, *Phys. Rev.*, **37**: 1263 and R. P. Winch, *Phys. Rev.*, **37**: 1269 (1931).

per primary near 300 volts incident energy. The decline beyond the maximum is very pronounced. These effects are characteristics of the contamination rather than of the metal. As the contamination is decreased by heating the target, the secondary emission decreases until it comes to a maximum of about one secondary per primary. The position of this low maximum and of the slope beyond it appear to be influenced by the metal, but the secondary emission is much less than would be obtained from a thoroughly heat treated target.

Further heating of the target increases the secondary emission, but the shape of the curve remains fairly stable, and is apparently characteristic of the metal. The change in the amount of secondary emission (presumably caused by the variation of the work function during the heat treatment) differs from metal to metal and is especially pronounced in the case of platinum.

A New Leather.—Mellon Institute of Industrial Research, Pittsburgh, has announced the successful completion of an extensive investigation by C. H. GEISTER, whose results are expected to be of great importance in the leather and shoe industries. This achievement is said to be the most outstanding scientific development in this field since Robert H. Foerderer created vici in the 1880's.

At a certain point in the vici method, a marked departure is taken from the usual treatment by impregnating the skin with an entirely new combination of materials. In this way the fibers are supported and lubricated, inhibiting their breaking down under wear—the cause of some leathers losing their shape when in use.

An important advantage of the new leather to the shoe manufacturer is that shoes fashioned from it require no dressing. When the shoes are completed, a buffer and friction brush bring out a rich finish of any desired brilliance. Furthermore, having no hard surface, the skins can be worked without the usual danger of shoe factory damage, greatly simplifying handling throughout the process of shoe manufacture.

The feature of this new leather that probably will be of most interest to the consumer is the permanence of its finish. The heat of the foot gradually but constantly encourages the impregnating materials to the surface, thus maintaining a lubricant on the grain which requires only a slight rubbing to preserve the desired polished effect. The impregnation also adds to the leather's water-resisting quality. This method also does away with the cracking common to leathers finished with hard surface dressings that powder and fly with wear.

All colors are said to be more permanent than is the case with hard-surface finish leathers because the color, like the finish, is constantly revitalized by the material with which the skin is impregnated.

Some of the other advantages are that the leather is more durable, practically scuff-proof, holds its shape, is soft and pliable to an unusual degree, yet retains the advantage of kid in permitting the foot to breathe.

WILLIAM PENN AS A BUSINESS MAN.

THE BUSINESS BACKGROUND IN ENGLAND, 1680–1682.*

BY

CHARLES LYON CHANDLER,

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In his valuable book, "The True William Penn," Sydney George Fisher says, "There must have been some special reason why Penn determined to act upon Fox's 1660 scheme and carry it out in 1680, but of this reason we are not informed and can only conjecture." May not the answer be found in Penn's taking advantage of the state of the market in 1680–1681? and may not another reason be that religious persecution was then at its height, not merely in England, but also in the whole of Continental Europe, except Brandenburg-Prussia? There is a very direct connection between the desire to emigrate and the intensity of religious persecution.

Let us first consider the general business conditions prevailing when Penn established his great enterprise with about the equivalent of $250,000 in our money today. It should be remembered that after Penn's father's death on Sept. 16, 1670, he was publicly acknowledged as a very rich young man; he had the equivalent of $30,000 a year.[1]

Some of the other American Colonies had been founded not merely in periods of business depression in England, but when prospects there had been none too good for initiating new Ventures. Their slow development—or failure—may be partially attributed to these reasons.

Business in London had been very good from 1678 to 1682, particularly about the time when Penn's Charter was granted in 1681, when there appears to have been a consider-

* A paper read before The Franklin Institute on Thursday, October 27, 1932, in connection with the celebration of the two hundred and fiftieth anniversary of Penn's landing in Philadelphia.

[1] Fisher, Sydney George, "The True William Penn," Phila., 1900, p. 151.

able amount of capital seeking profitable investment. The joint stock companies engaged in foreign trade had experienced ten years of good fortune. The stock of the East India Company went up from 434 guineas in 1680 to 460 in 1682, prior to their payment of the stock dividend of 100 per cent. The Royal African Company and the Hudson's Bay Company were not merely making considerable profits, but do not seem to have been materially affected by temporary domestic crises nor by the fluctuations in the London Stock Market. In the opinion of one of the greatest authorities on English business history, Professor W. R. Scott, "On the whole, the ten years from 1682 to 1691 were the most successful in the history of the English Foreign Trading Bodies." [2]

The permanent acquisition of New York by the English nine years previously had shown that England meant to keep what she had gained in the new world. English foreign trade had nearly doubled during the twenty years before Penn's sailing.[3]

Penn had many contacts with the business world in London—and Penn was our greatest Colonial advertiser, proclaiming his wares in not merely excellent English, but also in Dutch and German. His was the first attempt to advertise any part of what is now the United States on the Continent of Europe. A word about this advertising. Nicholas More, to whom most of what is now Montgomery County was granted by Penn, wrote Penn in September, 1686: "I have had seventy ears of rye upon one single root, proceeding from one single corn (he means grain), 45 of wheat, 80 of oats, 10, 12, and 14 of barley out of one grain. After saying that he grew above 3000 heads of oats from one grain, Nicholas adds: "But it would seem a romance rather than a truth if I should speak what I have seen in these things," [4] but the romance was turned into reality when we consider that the value of Philadelphia real estate increased by over 1000 per cent. between the first and second visits of Penn to Philadelphia. We must also bear in mind that Penn was the only founder of one of the 13 colonies which

[2] "Joint Stock Companies to 1720," Scott, Vol. 1, p. 317.

[3] Loc. cit., p. 316.

[4] Scharff and Westcott, Vol. 1, p. 150.

had any European, as contrasted with a purely English, background. His studies at the Protestant University at Saumur in France, under the celebrated French Protestant theologian, Moise Amyrault, a man far in advance of his contemporaries in breadth of view, exercised a great influence over him and undoubtedly contributed to enlarge and widen his mental outlook. Penn had that international vision which goes with an international mind.

Pennsylvania was founded when religious intolerance in England was at its height. There was no such thing as real religious toleration anywhere in Europe, except Brandenburg in Prussia under the Great Elector, Frederick William (1640–1688).[5]

Oliver Plunket, Catholic Archbishop of Armagh, in Ireland, had been hanged, drawn and quartered at London on July 1, 1681[6] four months after Penn's Charter had been granted, Archbishop Sharp, the Episcopal Bishop of Scotland, was dragged from his carriage and hacked to death before the eyes of his daughter on May 3, 1679;[7] and Russell and Sidney, two of the noblest men who ever lived in England, were hanged in December, 1683, when their friend William Penn was safely in Pennsylvania.

As a consequence of the Act of Parliament of August 24, 1662, a third of the Clergymen of the Church of England resigned their livings.

It would be more difficult to find a more bigoted Monarch in history than Charles II, who granted Penn his Charter for Pennsylvania. He was in the King business "for revenue only"; a personal coward, he was chasing a pretty moth when the Dutch sailed up the Medway in 1666. No wonder he wanted to get rid of Penn—and see him off to the New World. At least ten persons were put to death in Great Britain between 1551 and 1697 for publicly professing the ideas set forth by Penn in his "Sandy Foundation Shaken"[8] (1668), for which Penn was sent to the Tower; had it not been

[5] "Cambridge Modern History," Vol. V, p. 648.

[6] "Dictionary of National Biography," Vol. XLV, pp. 442–445..

[7] "Encyclopaedia Brittanica," 1911 Ed., Vol. XXIV, pp. 810–811.

[8] Wilbur, Earl Morse, "Our Unitarian Heritage," Boston, 1925, chapters 27, 28, 29.

for Penn's father's social position, he would have been hanged for denying the doctrine of the Trinity in England according to a law passed in 1648;[9] and had your speaker been living as a Unitarian in Maryland in 1682, he would, after his tongue had been bored through and he had been branded on the forehead, have been executed at the scaffold.[10]

We can hardly realize what it meant to the average Englishman in 1682 to hear that there was a place in His Majesty King Charles' Dominions where the laws governing religion were these:

> All persons living in this Province who confess and acknowledge the one Almighty and Eternal God to be the Creator, Upholder and Ruler of the World, and that hold themselves obliged in conscience to live peaceably and justly in civil society, shall in no ways be molested or prejudiced for their religious persuasion or practise in matters of faith and worship; nor shall they be compelled at any time to frequent or maintain any religious worship, place or ministry whatever.[11]

The above was re-enacted in the great law passed at Upland, alias Chester, on December 7, 1682, with the following important phrase added:

> "and if any person shall abuse or deride any other for his or her different persuasion and practise in the matter of religion such shall be looked upon as a disturber of the peace, and be punished accordingly."

Even international treaties guaranteeing some small measure of religious toleration were violated; Louis XIV of France so violated the Treaty of Westphalia.[12]

> To no other colony than Pennsylvania did Catholics, Lutherans, Presbyterians, Baptists and Episcopalians come on the same boat.

Among the eleven English Colonies on the Atlantic Seaboard (at the close of the seventeenth century) only Massachusetts antedated Pennsylvania in the establishment of a postal system; and the comprehensiveness and extent of that started by Penn seem to have excelled even that then existing

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[9] Wilbur, Earl Morse, "Our Unitarian Heritage," Boston 1925, chapters 27, 28, 29.

[10] See Channing, "History of the United States," Vol. II, p. 430, and Vol. V, p. 206.

[11] Pennsylvania Code of Laws promulgated May 16, 1682.

[12] "Cambridge Modern History," Vol. V., pp. 453–454.

in the Bay Colony. In 1683 Penn appointed Henry Waldy of Tekonay to keep a post and "supply passengers with horses from Philadelphia to New Castle or the Falls of the Delaware." From Philadelphia to Chester letters were carried under the service established by Penn for 2 pence, to New Castle for 4 pence and to points in Maryland for 6 pence.[13] Shortly afterwards, posts were established in practically every civilized community in the Quaker Colony of Pennsylvania.

Few of Penn's acts were more far-seeing, either as a business man or as an Empire-builder, than his stimulating the construction and development of roads and highways, which were non-existent in Pennsylvania on his arrival. Much was started along these lines by Penn on his first visit to his colony; by 1685 a road was open to Germantown; the one from Radnor to the Schuylkill was finished in 1687, and the York Road in 1693; the latter seems to have been extended to Bristol by 1700, when Penn was here again on his second visit. Though the Germantown Road was one of the first laid out, it took Isaac Norris' team all day to carry a load from Fair Hill to Philadelphia and back—a distance his descendant, who is with us tonight, can cover in an hour by automobile! Penn was thus a pioneer in intercolonial transportation, as well as a promoter thereof in his own colony. Much of the prosperity of Philadelphia in the first hundred years of its existence may be attributed to making it a great distributing center, as the hub of what for that time was such an excellent highway system. So far as can be ascertained, Penn was the only Colonial Governor to bring blooded horses to America; some noted steeds came over with him in 1699, and helped to improve the breed of Pennsylvania horses.

While the statement of John A. Doyle, the eminent English historian of the American Colonies, in the Cambridge Modern History, that "much of Penn's work has vanished," may be challenged from many points of view, we will all agree that he has correctly informed us that "one monument of his practical judgment and foresight abides. Alone among the leaders of English colonization in the seventeenth century, he can claim

[13] Information from the United States Post Office Department.

to be a *city founder*. That dignity, the result of symmetry and spaciousness, in which Philadelphia ranks above any city of its age and kind, is due to Penn's wise choice of a site and to his systematic construction."

The walnut, the hawthorn, and the hazel trees were added to Penn's woods by the Founder, who also caused to be imported and cultivated many fruit trees, seeds and roots;[14] in these activities we see Penn as the forerunner—again alone among Colonial Governors in this respect—of our Modern Department of Agriculture. The horses, cattle and sheep which the Swedes had already introduced along the Delaware as early as 1638 were a great help to Penn's Colonists. Few of us realize how much we owe the Swedes in this and other respects. Scarcely a "gainful occupation or trade" of contemporary England—or, for that matter, of western Europe—was unrepresented among Penn's early colonists. On one ship alone in 1683—that which brought Pastorius—came an apothecary, a glass blower, a mason, a smith, a cartwright, a joiner, a cooper, a hatter, a shoemaker, a tailor, a gardener; shipbuilding began at Philadelphia within a few months after Penn landed;[15] within six years exports were sent thence to the West Indies; and within fifteen years Philadelphia and Germantown had assumed a position in manufacturing unrivalled at that time in any other of the Colonies.

Another early Philadelphia industry leaped almost at once into intercolonial prominence. The first printing press to be set up in any colony outside of Massachusetts of which we have any definite and tangible information was that established by William Bradford at Philadelphia in 1686—[16] some say a year or two earlier. Bradford almost immediately began attacking his neighbor's beliefs and opinions in a manner highly inconsistent with the ideas of the Society of Friends, and was forced to transfer himself—and his press—to New York; but others took his place, and Philadelphia's continuous pride of place in the printing and publishing

[14] Fisher, Sydney George," The True William Penn," p. 253.

[15] Pennypacker, Samuel W., "The Settlement of Germantown," published by Wm. J. Campbell, Phila. 1879.

[16] See New York Times, Febr. 17, 1932.

business traces its origins, as do many other of its industries, to the foresight of William Penn.

Before making any allusion to the influence which William Penn's ideas and principles may have had on the United States Constitution of 1787, the following extract from a book published in London, in 1757, entitled "An Account of the European Settlements in America" (attributed to Edmund Burke), may be of interest:

> William Pen in his capacity of a divine, and of a moral writer, is certainly not of the first rank; and his works are of no great estimation, except amongst his own people; but in his capacity of a legislator, and the founder of so flourishing a commonwealth, which in the space of about seventy years, from a beginning of a few hundreds of refugees and indigent men, has grown to be a numerous and flourishing people; a people who from a perfect wilderness have brought their territory to a state of great cultivation, and filled it with wealthy and populous towns; and who in the midst of a fierce and lawless race of men, have preserved themselves with unarmed hands and passive principles, by the rules of moderation and justice, better than any other people has done by policy and arms.[17]

The significance of this statement lies in the fact that twenty years before the American Revolution broke out and thirty years before our Constitution was adopted, Penn's ideas and ideals were being accurately appraised.

An enormous amount of sentiment has been spent on an alleged treaty made by William Penn with the Indians. Not even the Landing of the Mayflower has been more frequently portrayed in a greater number of more utterly inexact and inaccurate representations.

Not merely does my learned friend, Albert Cook Myers, inform me that William Penn never made any treaty with the Indians, but even if he did do so in the year 1683 it could not possibly have been done in what appears to be the public square of a large city surrounded by neat five-story brick houses of the period of George III,—at least 50 years after William Penn had been laid to rest.

Another remarkable portrayal is that of William Penn on this occasion where he is represented as weighing nearly 300 pounds, attired in a hat never worn by any of the Society of Friends in 1683 and clad in garments which never, except at masquerades, were worn by any person at that time, and

[17] I am indebted to my valued friend Charles Penrose Esq. for this reference.

surmounted by a vivid lace sash carefully brought about his waist, which, if it was a part of anybody's uniform, was that of a Major General in the army at the time of Charles II. The writer has never seen any member of the Society of Friends on any occasion wear such a sash, or such beautifully starched ruffles as appear around the Immortal William. I quite agree with my old teacher, Professor Channing, that these representations are fantastic, as well as preposterous.[18]

These flippant statements of mine, which are but in the interest of historical accuracy, are not meant to detract in any way whatsoever from the ability and foresightedness of Penn in his dealings with the Indians. To be sure, he was very fortunate in meeting Indians who seemed to have been more or less of the non-massacre type, but he cannot be too highly praised for his relations with them. These had two very important practical results for the history of Pennsylvania. The first was that the Colonists were relatively little molested by the Indians. The second, which was even more important, was that through these bonds of friendship, at a period around 1750, Conrad Weiser and other interpreters were able to penetrate across the Ohio River into what is now the state of Ohio; in this manner materially contributing to the westward movement, not merely of Pennsylvania, but of the United States of America. It is safe to say that as a result of Penn's relations with the Indians this great westward movement, which has been so vividly described by the late President Roosevelt and others, could never have taken place.

In considering Penn as a business man, we should always remember that he knew how to conciliate when necessary, and millions of people who are now settled on the lands which he caused to be acquired for the white people from the Indians, either during his lifetime or after his death, have reason to bless his name for his tact and diplomacy.

William Penn had an extraordinary piece of luck in his early colonization of Pennsylvania. It is very generally known that he brought German immigrants with him and

[18] The late Sydney George Fisher in his valuable work entitled "The True William Penn," has some excellent comments on page 243 on the absurdity of some of the representations of our founder.

made every effort to induce people from all parts of Germany and also from Switzerland and Austria and other German-speaking countries to come to Pennsylvania. Through this movement the ancestors of President Hoover landed in Philadelphia about the time of Penn's death. It is not so generally known that in the very year 1682, when he landed here, the Elector of Prussia was actively preparing a number of colonies in Africa, in which the Prussian Government displayed for the first time that colonizing energy which was to burst forth again from Germany almost exactly 200 years later.[19] After investigating this matter it is little short of miraculous that at least a considerable number of the Germans who went to Pennsylvania were not diverted to Africa.

Piracy.—I promised our good friend, Dr. Howard McClenahan, that I would say something about My Lad Proprietor's relations with pirates. Penn was a good enough business man to cause most stringent legislation to be enacted in 1700 to put them down; for Philadelphia had grown so rich, attractive and comfortable that not merely did Avery and Blackbeard hover about the Delaware, but Governor Markham—Penn's relative—actually had a piratical son-in-law by the respectable name of James Brown. A pirate named Birmingham actually gave Markham some of his ill-gotten gains to invest for him! The relations of Markham with the pirates were most suspicious.

How much does the United States Constitution owe to William Penn? It seems to the writer that practically every fundamental principle in it had been foreseen by him, either in his plans for Pennsylvania, or in his other writings—no taxation without representation, religious liberty, representative government, encouragement of trade and commerce, "no cruel or unusual punishments," and other humanitarian provisions. We can also see Penn's influence fully as distinctly in what our Constitution avoids. Its aim was to set up a democratic government such as the best minds of 1787 understood it. Were not their thoughts influenced by what my Lord Proprietor had written and spoken one hundred years before?

[19] "Cambridge Modern History," Vol. V, p. 647.

"THE REFORMER"

BY RUDYARD KIPLING
1901

He shall forswear and put away
The idols of his sheltered house;
And to necessity shall pay
Unflinching tribute of his vows.

He shall not plead another's act,
Nor bind him in another's oath,
To weigh the Word above the Fact,
Or make or take excuse for sloth.

The yoke he bore shall press him still,
And long-ingrained effort goad
To find, to fashion and fulfil
The cleaner life, the sterner code.

Not in today his victory lies,
The world (unheeding his return)
Shall see it in his children's eyes,
And from his followers still shall learn.

THE TRI-DIMENSIONAL VIBROGRAPH.

BY

J. E. SHRADER.

Vibration problems during the last few years have become of great importance. One reason for this is the increased size of rotating machinery and the increased demands that these machines maintain their stability. This is especially true in the case of huge turbogenerators which have come into use in recent years. The cost of such machines is great and their maintenance is expensive and at this time when so much of our economic life is dependent upon electric service it is especially important that these expensive units give the greatest output of which they are capable without excessive wear and that their service should be uninterrupted. If such a machine should become seriously unbalanced service with the machine must be discontinued, and it must be overhauled or its life will be shortened because of excessive wear and weakness resulting from continuous vibration. Dangers due to excessive vibration are not confined to turbogenerators, but are common to most all forms of machinery in the shop or manufacturing plant.

Excessive vibration is a source of danger not only to machinery but also to the structure and foundations of the building in which such machinery is housed. In many cases even the disturbances set up by vibration may be transmitted to neighboring structures thereby endangering buildings in the immediate neighborhood. Last, but not necessarily least, is the bodily discomfort of the operator of machines and of persons whose duties require their presence near such disturbances.

Another annoying and often dangerous source of disturbance is due to vibrations as a result of heavy traffic in the crowded areas of our cities. The vibrations set up due to locomotives, subways, elevated trains and heavy trucks on the streets are transmitted through the solid strata of the

earth to neighboring buildings where these tremors are magnified in the structure so that such buildings may be endangered and their vibration may be a source of continual irritation to their occupants.

In earlier days and to a large extent even at the present time the correction of machines for vibration has been and is left to the individual engineer, whose judgment is based upon his physical sensations of touch, sight and sound which sensations cannot be relied upon with certainty. It is now realized by the responsible engineer that to make real progress in the elimination of these troubles it becomes necessary to put knowledge on a quantitative basis. Therefore, to prevent and cure excessive vibrations in a machine or in a structure more reliable means of measuring and recording vibrations must be used. The demands made upon such a piece of apparatus are that it should show:

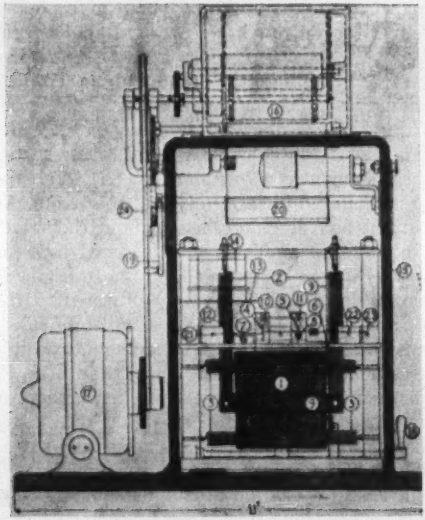
(1) Amplitude of vibrations in three directions,
(2) Frequency of vibration,
(3) Wave form of vibration,
(4) Phase relations of vibrations in three directions at right angles to each other.

The more common instruments now available for measuring vibration indicate amplitude of vibration in one direction. A few others record amplitude and wave form in only one direction. This type of instrument usually employs a pen or stylus recorder and there is great doubt as to whether a comparatively heavy pen or stylus records accurately the higher frequency vibrations.

To meet the demands of the exacting engineer that all possible, accurate information regarding the operation of a machine, or other vibrating body be secured, a new instrument having novel and important features has been devised. This instrument has been tested over a period of several years, and has been found to be reliable. This instrument, the Tri-Dimensional Vibrograph, has been designed to record photographically on a moving film components of vibrations in three dimensions simultaneously. This record shows amplitude, wave form, phase relation, and frequency of the three components of vibration.

The Vibrograph is a form of seismograph. The essential feature of the instrument is a heavy cubic mass suspended in a frame by a system of springs. When the frame is caused to vibrate the suspended mass due to its inertia tends to remain at rest. Means are provided by which this relative motion in three directions mutually perpendicular to each other are indicated on a scale or are recorded on a photographic film.

FIG. 1.



The arrangements of the various parts of the Vibrograph are shown in Fig. 1. The mass (1) is supported vertically in the frame by four springs (2). It is held in position in the two horizontal directions by two pairs of springs (3) on each of four vertical sides. Free oscillations of the suspended mass are largely damped out by absorbent materials inserted in the coils of the springs.

The relative motion of the suspended mass and the frame is shown by the rotation of three spindles (4), (5) and (6)

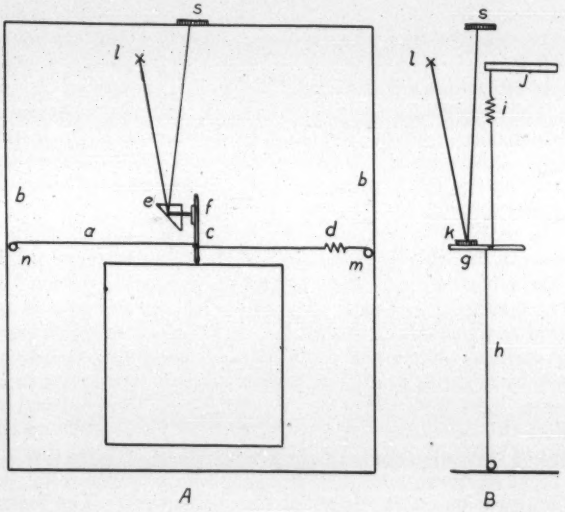
mounted upon the suspended mass. The rotation of each spindle is caused by a string, one end of which is fastened to the frame and is then wrapped about the spindle from which it passes to a short spiral spring fastened to the opposite side of the frame. Figure 2 (*A*) shows a simplified diagram of the arrangement for measuring vibrations in each of two horizontal directions at right angles to each other. For one of these directions a string (*a*) is fastened to the frame (*b*) after which it passes about the spindle (*c*) and extends to the spring (*d*) which is attached to the opposite part of the frame (*b*). Light from a lamp (*l*) is reflected by the right-angled prism (*e*) to the small concave mirror (*f*) of short focal length from which it is reflected back through the prism and is then brought to a focus on the scale (*S*). For the horizontal direction at right angles to this the arrangement is the same except that the string extends at right angles to the first. For vertical vibrations the arrangement is shown in Fig. 2 (*B*). In this case the spindle (*g*) is mounted horizontally and the string (*h*) extends vertically from the frame and passes about the spindle and is attached to the spring (*i*) which is fastened to a pin (*j*) attached to the upper part of the frame. Light from the same source (*l*) is reflected directly upward by the mirror (*k*) and is brought to a focus on the same scale (*S*).

The tension on the strings and the angular position of the mirror are controlled by adjusting pins (*j*) and (*m*) Fig. 2 (*a*). After adjustment, pin (*m*) rarely needs further attention. By turning pin (*n*) the image of the lamp is adjusted to the desired position on the scale. This adjustment changes the tension of the string slightly but not enought to interfere with the successful operation of the instrument. These controlling pins for the three strings are brought out on the front of the instrument and are provided with knobs and controlling levers.

To secure a timing record on a photographic film a fourth concave mirror is mounted stationary on the frame in such a manner that the light from the same lamp is brought to a focus on the same scale. Light from this mirror is intercepted once each cycle by a magnetic vibrator tuned to sixty cycle alternating current. In this manner the time is indicated on the film in the form of a broken line and the time between breaks is one sixtieth of a second.

The mass and its supporting frame are mounted in a cast aluminum housing. This housing has a removable front and back. An extension of the base provides a mount for a small electric motor. The photographic attachment is mounted on the top of the housing. Mounted inside the housing upon a shaft extending through its sides is a mirror which may be turned so as to intercept the light from the mirrors and reflect it for visual observation to a ground glass scale on the front of

FIG. 2.



the instrument. When a record is to be made the mirror is turned into a vertical position so that the light passes directly upward to the photographic recording apparatus.

The film holder consists of a light-tight cast aluminum box provided with means for driving a 70 mm. moving picture film. This film is carried from a spool at one side by a motor driven sprocket across a slit opening through which light enters from the mirrors. The film is then wound upon a spool

on the opposite side by a re-roll mechanism. The slit is ordinarily closed by a slotted cylindrical shutter. A revolution counter geared to the sprocket shaft indicates in inches the length of film that has been used during an exposure.

For visual observation of wave-form and amplitude of vibration a rotating mirror is provided which is interchangeable with the photographic attachment.

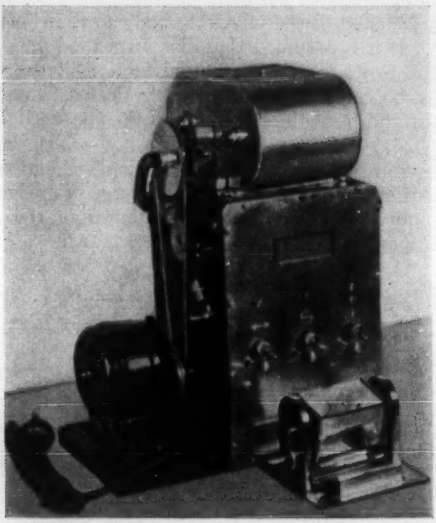
The photographic attachment and the rotating mirror are driven by a small induction motor mounted on the base of the instrument. The motor is provided with a receptacle and a switch and an ordinary light outlet serves as a source of power. To prevent the transmission of any vibration from the motor itself it is mounted on a system of springs by means of which these vibrations are absorbed.

The motor with proper reduction of speed by a system of gears drives an idling pulley located at the top of the instrument. A lever attached to the mirror shaft and connected to a cam on the idling shaft engages the driving mechanism to the film sprocket.

In making observations or records with the vibrograph shown by the photograph Fig. 3, it should be fastened firmly to the vibrating body in an approximately level position. A lever operating a clamping device beneath the mass, is released and the mass is allowed to swing freely on its supporting springs. Electrical connections to the instrument are made by inserting a plug to the receptacle and attaching to an electric light socket. With the reflecting mirror turned to reflect the light from the rotating mirrors to the scale on the front of the instrument the images formed by the mirrors are brought to the desired positions on the scale by turning the adjusting pins on the front of the instrument. The motor switch is then closed and the motor is brought to speed. The operating lever on the mirror shaft is then turned upward. By this motion the mirror is thrown out of the path of the light and the light passes upward through the slit of the photographic attachment whose shutter is opened automatically. At the same time the clutch on the idling shaft is engaged to the driving sprocket and the film is driven forward and is exposed to the beams of light coming through the slit from the three mirrors. When the desired length of film has

been exposed the controlling lever is pushed downward to its initial position. This motion disengages the clutch, closes the slit shutter and turns the reflecting mirror so that the beams of light are brought to the screen at the front for visual observation. The film is driven at the rate of about twelve inches per second and a record as short as six inches may be made. Since the photographic attachment will hold one hundred feet

FIG. 3.



of film an exposure as long as one hundred seconds may be made. It has been found that the optical system gives sufficient intensity of light that the less sensitive and less expensive positive double width motion picture film may be used. Any length of the exposed film may be removed and developed in the usual manner.

It is often desirable that a continuous record of vibration be made during the operation of a machine. For this purpose

a slow interchangeable photographic attachment has been made which makes a record on photographic paper at the rate of about one inch per hour. The photographic paper wound upon a spool may be inserted in the holder in daylight as in the daylight loading camera and after the desired length of exposure has been made it may be removed in daylight and taken to a dark room for development. The record of the slow recorder shows amplitude of vibration only of the three components and their variation over the period of exposure.

In taking a record with the vibrograph the frame should be firmly fastened to the vibrating body so that both vibrate together. If it is assumed that the suspended mass remains at rest due to its inertia the actual motion of the vibrating body may be calculated from the physical constants of the instrument and from the deflection of the spot of light on the scale.

When vibration occurs the linear displacement in any of the three directions produces an angular rotation of the mirror spindle and a beam of light falling upon the mirror is deflected upon the scale.

If

r = radius in inches of the mirror spindle,
R = distance in inches from the mirror to the scale,
D = scale reading in inches,
d = displacement of the vibrating body,

then angular displacement θ of the mirror spindle is given by the relation

$$\theta = \frac{d}{r}.$$

The spot of light falling upon the mirror is reflected through twice this angle and for small angles

$$2\theta = D/R \text{ or } \theta = \frac{D}{2R}.$$

Hence, $d/r = D/2R$ and, the double amplitude of vibration in inches of the vibrating body is given by

$$d = \frac{r}{2R} D.$$

For a particular instrument designed to meet the requirements for ordinary purposes the factor $\frac{r}{2R} = \frac{1}{300}$. Hence, if the scale is marked off in intervals of 0.33 of an inch each of these intervals will measure 0.001 inch of motion of the vibrating body.

It has here been assumed that no motion has been communicated from the vibrating body to the suspended mass. This condition is hard to realize in practice and for this reason the suspended body will have a tendency to vibrate at its own natural frequency. The amplitude of this vibration will be dependent upon the frequency of the vibrating body and the natural frequency of the suspended mass. It can be shown that if the ratio of the frequency of the vibrating body to the natural frequency of the suspended mass is four the error in measurement of amplitude of vibration of the vibrating body is not greater than six per cent. As this ratio becomes larger the error in measurement of amplitude becomes smaller. Hence to measure amplitudes of vibration with a fair degree of accuracy the natural frequency of vibration of the suspended mass should be kept as low as possible.

The natural frequency of vibration of a mass suspended by a spring depends upon two factors, namely:

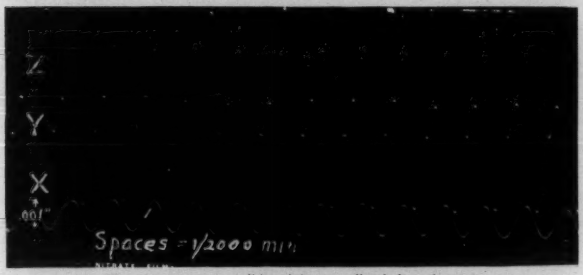
(1) The spring constant K or force per unit extension,
(2) The mass M of the suspended body.

If there is no damping force the frequency of vibration of the suspended mass varies as the square root of K/M. Therefore, to make the natural frequency of the suspended body low the mass should be large and the springs should be weak and as long as can be conveniently used.

To minimize inaccuracy due to vibration of the suspended mass a damping factor may be introduced which brings into action a force which tends to resist free vibration of the mass. Damping is secured in the instrument by introducing strips of felt inside the coiled springs.

Often a stylus or pen recorder is used in certain forms of vibrographs. The use of this mechanism may seriously affect the accuracy of an instrument of this kind especially when used for recording vibrations of the higher frequencies.

FIG. 4.

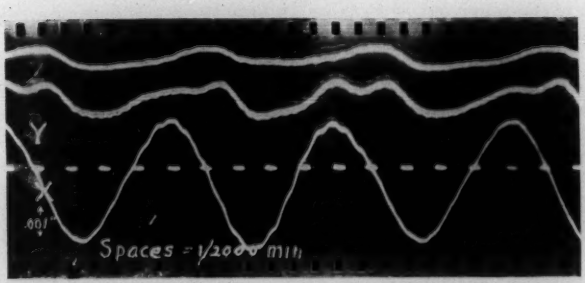


Vibrations set up in wall bench by a small unbalanced motor.

FIG. 5.

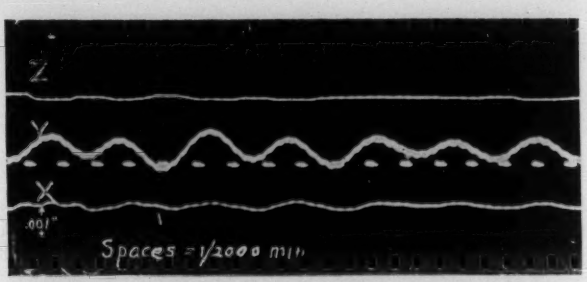
Vibrations in table top set up by small unbalanced motor.

FIG. 6.



Vibrations in 15 in. gas main due to pumping gas through it.

FIG. 7.

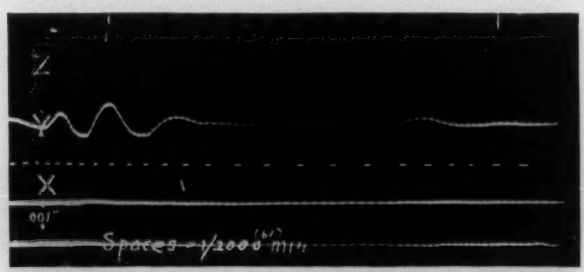


Vibration in dwelling house due to traffic. *Y*-component perpendicular to the wall.

FIG. 8.

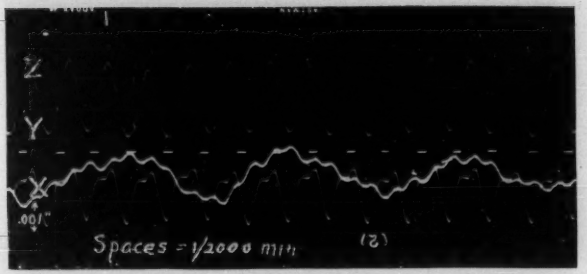
Vibration of 4-cylinder Diesel engine running at 375 r.p.m. with a load of 33 K.W. on direct connected generator.

FIG. 9.



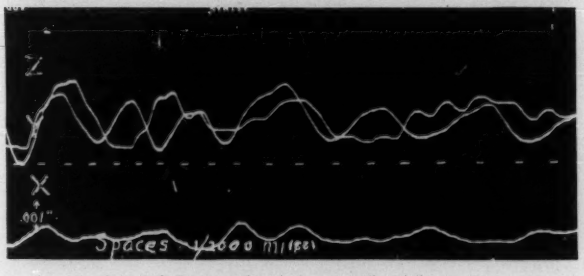
Vibration due to traffic in concourse of P. R. R. Suburban Station, 16th St., Philadelphia. *Z*-component is vertical. The Station Building had been isolated on its foundations and showed no vibration.

FIG. 10.



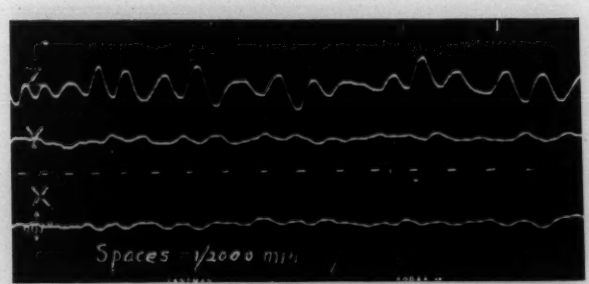
Record of vibration on bearing no. 2 of a large turbogenerator at 1800 r.p.m. with a load of 53000 K.W.

FIG. 11.



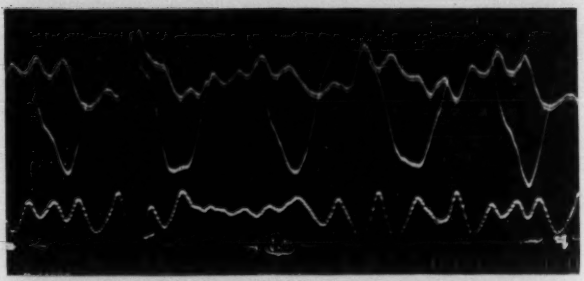
Record of vibration at front in an automobile at idling speed.

FIG. 12.



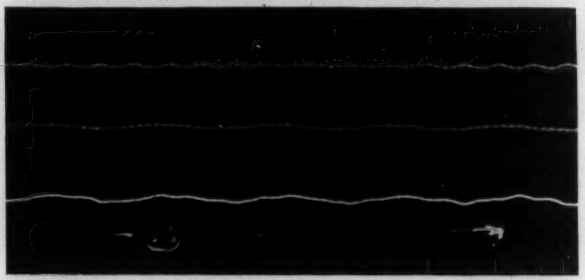
Record of vibration in front of same automobile as Fig. 8, at engine speed of about 35 m.p.h.

FIG. 13.



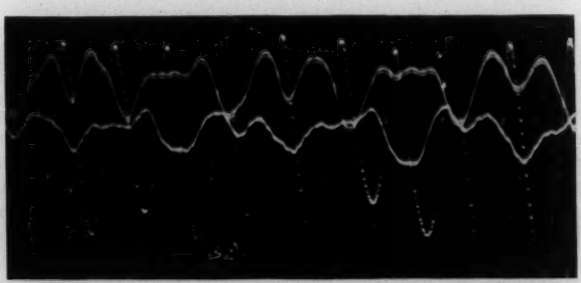
Record of vibration made on the foundation of a Diesel engine at a speed of 518 r.p.m.

FIG. 14.



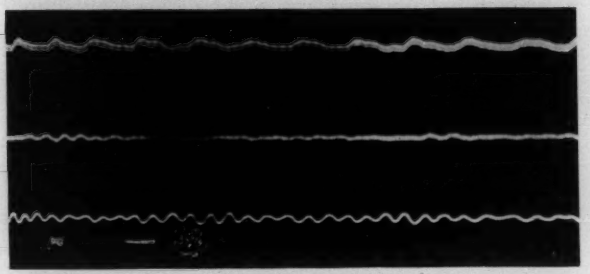
Record of vibration at a point across the Vibracork which separated the Diesel engine (Fig. 10) and foundation from the balance of the building.

FIG. 15.



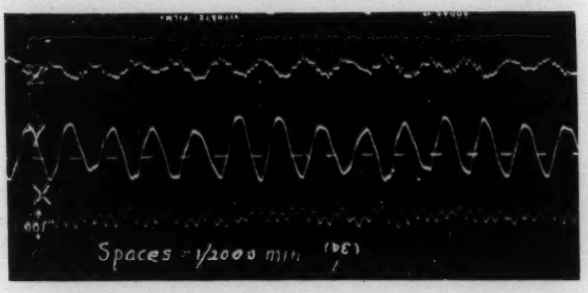
Record of vibration on the foundation of a 4-cylinder Diesel engine running at 547 r.p.m., no load, the adjacent engine carrying the load.

FIG. 16.



Record of vibration in the engine room adjacent to two Diesel engines (Fig. 12) which are isolated with Vibracork.

FIG. 17.



Record of vibration of centrifugal pump, 250 lbs/in.² pressure, full load.

Such recorders usually are of such great mass that they will not respond to the frequencies that they are called upon to record. It may be true also that if these recorders are long and not sufficiently rigid they may have a vibration frequency of their own which is superimposed upon that of the vibration which is to be recorded. The instrument here described has no heavy recording parts. The record is made by a beam of light reflected from a small mirror mounted on the axis of a small spindle of very small moment of inertia. For this

reason the recording system readily responds to quite large amplitudes and high frequencies of vibration.

The advantages of the type of instrument here described may be summarized as follows:

1. The instrument records amplitudes, frequency, wave form and phase relation of the three components of vibration simultaneously without change in position or adjustment.

2. A true response to a large range of frequencies is secured by the use of light moving parts, a small spindle carrying a mirror and a beam of light for making a record instead of a relatively large pen or stylus.

3. The instrument is simple to operate. Few adjustments are required and the operations in making a record are nearly automatic. For this reason a skilled operator is not required and good results may be secured by the ordinary operator.

A number of records of vibration have been made with the Tri-Dimensional Vibrograph produced by various causes and under various conditions. Several of these records are appended together with a brief statement as to their source and the conditions under which they were made.

The time intervals in these records were made with a small synchronous motor instead of a vibrator and the time between spaces is 1/2000 of a minute.

X, *Y*, and *Z* are components lengthwise, sidewise and vertical, respectively, with respect to the instrument.

I wish to express my thanks to the Philadelphia Electric Company under whose sponsorship the greater part of the development of the instrument here described was carried out.

Gulf Stream Overrated as a Maker of Weather.—(U. S. Dept. of Agriculture, Clip Sheet No. 767.) The Gulf Stream is not responsible for the changes in America's climate popularly attributed to it, says the Weather Bureau, United States Department of Agriculture. The true course of this "river of the sea" is shown in a chart recently prepared by the bureau's marine division from its long-time records of the temperature of north Atlantic waters. Although the current preserves its identity in the Florida straits, it merges more and more with the vast north Atlantic circulation as it goes north.

The contrast between the high temperature which the Gulf Stream carries up from below Cape Hatteras and the low temperatures coming in from the open Atlantic around the Grand Banks of Newfoundland produces a rather sharp margin in current and temperature, the warmer water flowing northeast past the colder water that moves more sluggishly southwest. This contrast is most marked in winter.

Only in winter is the Gulf Stream accompanied by temperatures far above those of the surrounding waters, the map shows. The effects of the Gulf Stream on the weather are more pronounced in Europe than in the United States, although it does exert some influence along the southern part of its course. The Gulf Stream is not responsible for the predominance of mild winters along our eastern seaboard since about 1905. The climate there, the Federal weathermen point out, is the result more of what happens over the land to the north and west than of what happens over the sea to the south and east.

NOTES FROM THE U. S. BUREAU OF STANDARDS.*

INTERNATIONAL ACTION ON UNITS IN ELECTRICITY AND LIGHT.

The Advisory Committee on Electricity and Photometry, established by the International Committee on Weights and Measures, held its third biennial meeting at Paris, January 31 to February 3. The committee consists of representatives of France, Germany, Great Britain, Italy, Japan, the United States and the U. S. S. R. (Russia). All except the Russian representative attended this meeting. Specially invited experts from Holland were also present, as well as representatives of the International Bureau of Weights and Measures and of the International Commission on Illumination.

As was stated in Technical News Bulletin No. 190 (February, 1933), the principal purpose of this meeting was to fix dates on which new units in electricity and light might be internationally accepted for general use, and to make a definite plan for the comparisons and interchange of standards which will be necessary to assure uniformity of values among the different countries.

The conclusions reached are subject to ratification by the International Committee on Weights and Measures, and on some matters of principle it is considered necessary to obtain also the approval of the General Conference of 32 nations which is the ultimate authority. Both of these bodies meet in the fall of 1933.

The authority of the International Committee to take up photometry under the terms of the existing treaty has been questioned, and the appointment of a single advisory committee to deal with this subject as an adjunct of electricity has been criticized. Consequently it is proposed to ask the General Conference to authorize the appointment of a separate advisory committee on photometry. In the meantime, however, the present committee has collaborated with a special committee on units and standards appointed by the

* Communicated by the Director.

International Commission on Illumination, and consisting of representatives from the national committees on illumination in France, Germany, Great Britain, Holland, Japan, and the United States. With the advice of this group of specialists, considerable progress was made at this meeting toward agreement upon a uniform international system of photometry.

The formal recommendations to be submitted to the International Committee on Weights and Measures, translated from the official French text, are as follows:

A. Electrical units and standards.

1. (*a*) The Advisory Committee confirms the opinion that the absolute system of electrical units should be definitively substituted for the present international system and believes that the International Committee should ask the General Conference on Weights and Measures to approve the principle of this substitution.

(*b*) Since some of the national laboratories have not yet completed the measurements needed to connect the international units with the absolute units, the Advisory Committee proposes to postpone until the year 1935 the provisional establishment of the ratio between each international unit and the corresponding absolute unit.

(*c*) It expresses the wish that at that date the International Committee shall have obtained from the General Conference the necessary powers to fix these ratios, as well as the date of adoption of the new units, without awaiting another conference.

2. (*a*) Although it may not be possible at present to attain a precision better than a part in 100,000 in the absolute determinations, the Advisory Committee believes that for the practical use of laboratories of precision there is reason to assign to standards of resistance and of electromotive force values expressed to a part in one million.

(*b*) The Advisory Committee requests the laboratories represented in its membership to appoint members of a technical subcommittee to make comparisons of resistance standards and standard cells with such precision as is necessary and to fix their values in absolute units. The president of the Advisory Committee is requested to

assume the presidency of the subcommittee or to designate a member to act in that capacity.

(*c*) The Advisory Committee proposes that the technical subcommittee shall meet at the International Bureau of Weights and Measures during the year 1935.

(*d*) The Advisory Committee requests each laboratory to send for the comparisons at least three resistance standards and at least ten standard cells, accompanied by a record showing the successive values which have been found for each standard since its construction. It will be desirable for those laboratories, which have completed absolute determinations, to send a larger number of standards, indicating their values as determined by the absolute measurements.

(*e*) In fixing the values to be assigned to the standards, the subcommittee shall choose the most probable value, after discussing the precision obtained by different methods in the several determinations.

(*f*) The subcommittee shall assign a value for each resistance standard and each standard cell included in the comparisons.

(*g*) Every proposal of the technical subcommittee shall be subject to the approval of the Advisory Committee before being presented to the International Committee on Weights and Measures.

3. The Advisory Committee having considered the observations of Professor Cohen (of Utrecht) on the metastability shown at temperatures below 12° C. by standard cells with 12.5 per cent. of cadmium in the amalgam, while a 10 per cent. amalgam does not present this undesirable characteristic, does not feel that it is necessary now to modify the specifications given by the London Conference of 1908, but brings this circumstance to the attention of the different laboratories concerned so that they may take account of it in the future construction of cells.

B. Photometry.

1. (*a*) The Advisory Committee, while maintaining the opinion expressed in 1930 that the primary unit of luminous intensity should be based upon the radiation of the black body, believes that it would be premature at the present time to give specifications for such a standard.

(*b*) Nevertheless, it believes that the necessity of connecting the chosen primary standard with the units now in use will require fixing the brightness of a black-body radiator operating at a temperature near to the color-temperature of the carbon-filament lamps now used to preserve the unit of intensity.

(*c*) The committee proposes to choose for this purpose the temperature of solidification of platinum and it invites all the national laboratories which have not yet determined the brightness of the black body at this temperature to do so before 1935.

(*d*) It expresses the desire that the International Committee seek from the General Conference on Weights and Measures the power to fix at a suitable time the brightness of the black body at the temperature of solidification of platinum and the specifications to be followed in the realization of a black-body standard of light.

2. (*a*) The committee believes that the problem of heterochromatic photometry can be solved only by fixing a priori a curve of factors of visibility. It suggests that the International Committee on Weights and Measures adopt the factors of visibility proposed by Gibson and Tyndall and approved by the International Commission on Illumination at its 1924 session.

(*b*) These factors are as follows:

Values of Relative Visibility.
(Unity at wave-length of maximum visibility.)

Wave-length in Millimicrons.	Relative Visibility.	Wave-length in Millimicrons.	Relative Visibility.
400	0.0004	600	0.631
10	0.0012	10	0.503
20	0.0040	20	0.381
30	0.0116	30	0.265
40	0.023	40	0.175
450	0.038	650	0.107
60	0.060	60	0.061
70	0.091	70	0.032
80	0.139	80	0.017
90	0.208	90	0.0082
500	0.323	700	0.0041
10	0.503	10	0.0021
20	0.710	20	0.00105
30	0.862	30	0.00052
40	0.954	40	0.00025
550	0.995	750	0.00012
60	0.995	60	0.00006
70	0.952		
80	0.870		
90	0.757		

(*c*) The Advisory Committee expresses the wish that the International Committee shall fix the procedure for use of these factors with the counsel of the Advisory Committee and by agreement with the national laboratories and the International Commission on Illumination.

3. The Advisory Committee recommends that the national laboratories exchange lamps on which they shall have determined the ratio between the luminous flux and the intensity in a specified direction. Each laboratory should describe the methods used in determining this ratio.

The interchange of lamps in accordance with resolution 3 is expected to locate the cause of serious discrepancies which now exist between different countries in the measurement of total flux of light, without waiting for the settlement of the photometric difficulties arising from differences of color of light. The progress made toward solution of the latter problem is not fully reflected in the formal resolutions, because in fact agreement was reached informally on precise transmission factors for certain blue glass filters which will

serve to connect measurements on modern lamps of high efficiency with the basic candlepower standards, giving a system of standard lamps in accordance with the visibility factors recommended in resolution 2.

ALCOHOL AS MOTOR FUEL.

Ethyl or grain alcohol can be used as a substitute for gasoline in automobile engines, although such engines cannot be started cold with alcohol alone in freezing weather.

When used in the same engine, gasoline and alcohol will deliver about the same maximum horsepower. Since alcohol contains less energy than gasoline, the engine, when suitably adjusted to give maximum horsepower with each fuel, will require about one and one-half gallons of alcohol to equal one gallon of gasoline in total power output.

When alcohol is mixed or blended with gasoline, there is for each blend some temperature below which the mixture will separate into layers: the upper layer being mainly gasoline and the lower layer mostly alcohol. The smaller the proportion of alcohol in the blend and the greater the content of water in the alcohol used, the higher will be the temperature of separation. Thus, using commercial 95 per cent. alcohol, mixtures containing less than 25 per cent. of alcohol will separate at ordinary temperatures.

To make alcohol-gasoline blends containing less than 10 per cent. of alcohol, it is necessary to use absolute alcohol or to add some blending agent such as ether, acetone, aromatics, or higher alcohols. If such mixtures collect small amounts of moisture by leakage or "sweating" of tanks, they will separate into two layers with the alcohol at the bottom. Under these conditions, carburetor trouble would be experienced and starting might be impossible in cold weather. The development of more efficient blending agents may reduce the tendency of absorbed moisture to cause separation of alcohol-gasoline blends.

Blends of alcohol and gasoline containing less than 15 per cent. of alcohol sometimes can be substituted for gasoline without readjustment of carburetors. These blends give leaner fuel-air mixtures than gasoline alone, hence if the car-

buretor is adjusted for an over-rich mixture, as is commonly the case, the alcohol blend substituted for gasoline may give equal fuel economy.

Alcohol is an anti-knock fuel and alcohol-gasoline blends knock less readily than the same gasoline without the alcohol; therefore they can be used in high-compression engines. The addition of 15 per cent. of alcohol to a gasoline will improve its knock rating about as much as the difference between the usual premium and non-premium gasolines, or about three cents worth at retail prices.

Alcohol and fuels containing alcohol may be corrosive to some metals used in fuel tanks and fuel lines although not sufficiently so to prevent the use of such fuels in cars as they are now made. New fuel systems designed for use with alcohol-gasoline blends should be made from metals not subject to this corrosion.

Ethyl alcohol can be made from grain, potatoes, molasses, or from various vegetable by-products. It can be made also from natural gas and from by-products of the distillation of petroleum or coal. To produce one gallon of alcohol requires about 25 pounds of either grain or molasses hence the cost per gallon of alcohol from these sources can hardly be less than the cost of 25 pounds of grain or molasses. This permits a comparison between the cost of alcohol and gasoline.

In certain countries the cost per gallon of gasoline considerably exceeds that of alcohol. Under such conditions the use of alcohol-gasoline blends for fuel purposes is economically justified provided the technical difficulties are satisfactorily met.

INFRA-RED RADIATION FROM AN ENGINE CYLINDER.

Whenever a mixture of fuel and air is exploded in an engine cylinder a certain amount of energy is emitted in the form of radiation, part of this radiant energy being visible and defining what is referred to as the "flame." Observations of the manner in which the "flame" traverses an engine cylinder have been made at the bureau, using a specially designed head fitted with 31 symmetrically spaced windows (each giving a view perpendicular to the direction of flame travel) and a stroboscope arranged to give a view of the head

once each engine cycle at a predetermined moment. In this way it has been possible to determine the position of the visible "flame" in the cylinder any time after the passage of the spark.

The greater part of the radiant energy from flames is, however, invisible and manifests itself in the infra-red region of the spectrum. In a paper to appear shortly in *Industrial and Engineering Chemistry* work on infra-red radiation from an engine cylinder is described.

Infra-red radiation is emitted whenever a substance is heated and varies with the temperature: moreover, the infra-red radiation from flames and explosions depends on the substances formed during the combustion, not on those burnt. For example, carbon dioxide and water vapor are formed in both acetylene and illuminating gas flames and can be detected by their characteristic emission bands in the infra-red region, just as other substances may be detected by their characteristic lines in the visible and ultra-violet regions.

Knowing the time of arrival of the "flame" under a given window in the engine head it is hoped, by measuring infra-red radiation through this window prior and subsequent to this moment, that some of the mysteries of combustion may be elucidated. In particular the time between the arrival of the flame under a selected window and the detection of carbon dioxide gives a measure of the so-called "reaction zone," while the differences in radiation from different parts of the cylinder, with and without fuel-knock, may well throw light on the phenomenon of fuel-knock in automobile engines.

EFFECT OF TEMPERATURE ON ELASTIC PROPERTIES OF METALS USED FOR AIRCRAFT INSTRUMENTS.

One requirement of aircraft instruments is that their indications be independent of temperature in the range $-50°$ to $+50°$ C. Since the effect of temperature on instruments of correct mechanical design is due largely to the change in the elastic moduli with temperature of the elastic elements, data on this effect for materials of possible use in constructing elastic elements are of prime importance. The effect is most conveniently presented as a coefficient which is the rate of

change of the elastic modulus with temperature divided by the elastic modulus.

As an example, consider the indicator of an air speed meter of the pitot-static tube type. For a diaphragm of such an indicator, made of a material having a temperature coefficient of elasticity of -40×10^{-5} per ° C., the change in reading in units of speed is computed to be $20 \times 10^{-3} \times 80$ or 1.6 per cent. for a change in temperature of 80° C. That is, at 100 m.p.h. the instrument will read 1.6 m.p.h. less if the temperature is reduced from, say, $+45°$ to $-35°$ C. This knowledge enables the performance to be specified to allow for this error, if the expense of compensation is to be avoided, and enables the manufacturer to separate the error from this cause from other possible temperature effects.

In Research Paper No. 531, to be published in the March number of the *Bureau of Standards Journal of Research*, experiments are described which were made at the bureau in coöperation with the National Advisory Committee for Aeronautics and which extend the work carried on by Brombacher and Melton, and published as N.A.C.A. Technical Report No. 538. In these earlier experiments only the temperature coefficient of the rigidity modulus was determined in the range $-20°$ to $+50°$ C. In the present experiments the temperature coefficients of the elastic moduli were determined in the temperature range $-50°$ to $+50°$ C. for three phosphor bronzes, six nickel silvers, monel metal, duralumin, brass, beryllium bronze, tungsten, seven high carbon steels, and ten alloy steels. The materials were selected on the basis of their possible use as elastic elements for aircraft and other instruments. In most cases the coefficients were determined with the metal in the condition of heat treatment or cold work most suitable for its use as an elastic element and also in the annealed condition. The coefficient of each modulus at 0° C., the ratio of the coefficient at $+25$ to that at $-25°$ C., the composition, and the heat treated or cold worked condition is given for each sample.

The method of experimentation differed from that usually followed and has many advantages. Two helical springs of a given material and the same design were coupled together and (*a*) stressed in tension to obtain the temperature coefficient of

the rigidity modulus, and (*b*) stressed in twist to obtain the temperature coefficient of Young's modulus of elasticity. While under each type of stress the change in the deformation of the springs of the coupled system was measured as the temperature of one of the springs was varied while that of the other was maintained constant.

MEASUREMENT OF FLUCTUATIONS OF AIR SPEED IN TURBULENT FLOW.

Further advances in the knowledge of the flow of air are dependent on the experimental determination of the character and magnitude of the fluctuations of the air speed about its mean value in turbulent air flow. The bureau, in coöperation with the National Advisory Committee for Aeronautics, has been active in the development of apparatus for making such measurements. The central element is a platinum wire about 0.015 mm. in diameter and 7 mm. long, which is heated electrically. Fluctuations of the speed of air flowing past the wire produce fluctuations of the temperature and hence of the electrical resistance of the wire. For small fluctuations of speed, the changes in resistance are small and means must be provided for amplifying the small voltage fluctuations produced by the changes in resistance. Furthermore, even such a small wire does not correctly follow rapid fluctuations of air speed. A method of compensating for this defect of the hot wire anemometer was developed several years ago at the bureau. The method consists in the introduction of a special compensating circuit in the amplifier, which acts to give the combination of hot wire and amplifier a uniform response to fluctuations of a given magnitude over a wide range of frequencies.

Within the last two years numerous improvements have been made in the design of the amplifier and compensating circuit, and the performance of the equipment has been investigated, using a method developed by Ziegler. Technical Report No. 448 of the National Advisory Committee for Aeronautics, which has just been published, describes these improvements, the requirements and methods of design of amplifiers and compensating circuits, and gives the performance data of the equipment now in use at the Bureau of Stand-

ards. Frequencies from 25 to several thousand cycles per second are correctly reproduced.

CHANGE IN SCHEDULE OF RADIO TRANSMISSIONS OF STANDARD FREQUENCY.

The bureau transmits standard frequencies from its station WWV, Beltsville, Md., every Tuesday. The transmissions are on 5,000 kilocycles per second. Beginning April 1, the schedule will be changed. The transmissions will be given continuously from 12 noon to 2 P.M. and from 10:00 P.M. to midnight, Eastern Standard Time. (From October to March the schedule was from 10 A.M. to 12 noon, and from 8 to 10 P.M.) The service may be used by transmitting stations in adjusting their transmitters to exact frequency, and by the public in calibrating frequency standards, and transmitting and receiving apparatus. The transmissions can be heard and utilized by stations equipped for continuous-wave reception throughout the United States, although not with certainty in some places. The accuracy of the frequency is at all times better than one cycle per second (one in five million).

From the 5,000 kilocycles any frequency may be checked by the method of harmonics. Information on how to receive and utilize the signals is given in a pamphlet obtainable on request addressed to Bureau of Standards, Washington, D. C.

The transmissions consist mainly of continuous, unkeyed carrier frequency, giving a continuous whistle in the phones when received with an oscillating receiving set. For the first five minutes the general call (CQ de WWV) and announcement of the frequency are transmitted. The frequency and the call letters of the station (WWV) are given every ten minutes thereafter.

Supplementary experimental transmissions are made at other times. Some of these are made at higher frequencies and some with modulated waves, probably modulated at 10 kc. Information regarding proposed supplementary transmissions is given by radio during the regular transmissions.

The bureau desires to receive reports on the transmissions, especially because radio transmission phenomena change with the season of the year. The data desired are approximate field intensity, fading characteristics, and the suitability of the

transmissions for frequency measurements. It is suggested that in reporting on intensities, the following designations be used where field intensity measurement apparatus is not used: (1) hardly perceptible, unreadable; (2) weak, readable now and then; (3) fairly good, readable with difficulty; (4) good, readable; (5) very good, perfectly readable. A statement as to whether fading is present or not is desired, and if so, its characteristics, such as time between peaks of signal intensity. Statements as to type of receiving set and type of antenna used are also desired. The bureau would also appreciate reports on the use of the transmissions for purposes of frequency measurement or control.

All reports and letters regarding the transmissions should be addressed Bureau of Standards, Washington, D. C.

COLORED WATERPROOF DRAWING INKS.

The bureau has, at the request of a Government department, recently completed work on the preparation of a number of water-fast drawing inks which do not deteriorate on storage for a period of at least one year.

These inks consist of an aqueous five per cent. shellac solution to which has been added a small quantity of phenol, borax, and a dye. The shellac used was not bleached but was freed from natural waxes and dirt. Of 92 dyes investigated, only 17 were found to be at all suitable for this purpose. Of the 17, seven were selected, each of which produces an ink of a different color.

Of several different methods of testing the fastness to water the most satisfactory consists in marking strips of paper with the inks, covering them with moist filter papers and placing the strip and filter paper between dry glass plates. Thus the "running" of the dye can easily be detected and comparisons made between different inks. Under this treatment the seven selected dyes "bled" or "ran" very little if at all.

OHIO CLAYS.

In the investigation of the characteristics of Ohio clays just being completed at the Columbus branch of the bureau, it was found in the case of shales and glacial clays that a rather

uniform variation exists between the pyrometric cone equivalents of the clays and the sum of the mineral constituents, orthoclase, kaolinite, and quartz. The percentage of minerals present in the clays was determined by calculation from the chemical analysis. The P. C. E. was found to increase as the sum of the percentages of these minerals increased. Also there seems to be a tendency for the sum of the kaolinite and quartz percentages to increase as the percentage of orthoclase decreases, although not in the same ratio.

In the 18 clays examined in this respect the orthoclase varied from 8.6 to 21.7 per cent.; the kaolinite from 9.1 to 45.6 per cent.; and the quartz from 19.0 to 53.8 per cent. The sum of the percentages of these three minerals varies from 54.4 to 86.3 per cent. the remainder being largely lime, magnesium, and iron bearing minerals. The P. C. E. values vary from cone 3 to cone 14–15.

FEDERAL SPECIFICATIONS FOR FIRE-CLAY BRICK.

Several important changes have been made in Specification HH–B–671 for fire-clay brick. The provisions in the revised Specification, HH–B–671a, will become mandatory for all departments of the Federal Government in the purchase of firebrick not later than April 15, 1933.

The revised specification is different from the one it replaces as follows:

1. The number of classes of bricks has been reduced from 6 to 4, and siliceous brick (over 65 per cent. silica) is now included in Class H–75. However, the requirements for the siliceous type of brick shall only apply when specified in invitations for bids.

2. The softening point or P. C. E. requirement of bricks in Class SH–75 has been increased from 31 to 32.

3. The requirements of the quenching test for bricks of Class SH–75 now specify 18 cycles without failure instead of 15.

4. Bricks for the thermal spalling test are placed in the door of the furnace so that only one end is reheated instead of the entire brick. The brick will be quenched in two inches of water instead of four inches as formerly. No changes were made in temperature of reheat or quenching.

5. When special shapes are furnished in excess of 2,500 nine-inch equivalents, it will be necessary to include standard 9-inch brick of the same composition for the thermal spalling test.

STUDIES OF MASONRY CEMENTS—WORKABILITY.

One section covered by the general investigation of masonry cements conducted by the cement section of the bureau, is a study of the "workability" of masonry cement mortars. Various opinions have been advanced as to the properties included in such a term and there is no exact definition that can be mathematically expressed. However, the difficulty of defining such a property, that is not mathematically expressed but is intuitively recognized by experts, fortunately does not preclude the efforts of investigators in the laboratory from developing their own concepts.

Qualitatively, plasticity can be described as the inherent resistance of a body to shear. This idea has been used in measuring viscous and plastic masses. The McMichael viscosimeter was developed for the purpose of measuring this resistance in viscous masses. The principle is, briefly, to measure the torque on a disc submerged in the mass under study when the mass itself is rotated. Such an instrument offered a principle that appeared to eliminate within reasonable limits the objectionable feature of segregation of mixtures of solids and liquids because of its motion, but as is usually the case, it underwent many changes before becoming a satisfactory device for the specific problem at hand.

The machine now consists of a cup about 5 inches deep and 4 inches in diameter with three rows of four teeth each stepped up radially on the inside. A toothed paddle not unlike the paddles in the old time ice-cream freezer meshes with the teeth fastened to the cup. The paddle shaft is connected to a balance. The cup is filled with mortar and rotated at a constant speed. The rotational force is transmitted from the cup to the paddle through the mortar. The balance measures the force necessary to keep the paddle stationary,—or it can be said that it measures a function of the shear.

One mortar mixture was used, viz., 1 : 3 by weight of standard sand. Water was added by 1 per cent. increments,

(calculated by weight of dry materials). A fresh batch of mortar was used for each set of measurements. The cup was rotated at three different speeds, and these speeds were repeated three times on the same batch of mortar. The limits of the water content were the limits of the device, i.e., when the mix was too dry, large lumps were thrown out of the cup, when too wet, the solids settled.

The data were plotted on semi-logarithmic paper; the torque values on the ordinates and the percentage of mixing water on the abscissa. All the data produced straight lines with a negative slope. The following equation was derived:

$$\text{Log. of torque} = \frac{\log (1200) - \log (200)}{K_1(W_{\text{max.}} - W_{\text{min.}})} x + \frac{W_{\text{min.}}}{K_2}.$$

Torque values, maximum and minimum, respectively, of 1,200 and 200 approximated closely the dry and wet limits of the mortar.

$W_{\text{max.}}$ = maximum amount of water used in terms of percentage of dry materials.

$W_{\text{min.}}$ = minimum amount of water used in terms of percentage of dry materials.

x = the amount of water added in terms of percentage of dry materials anywhere between the maximum and minimum amounts.

K_1 and K_2 are constants.

This equation shows that different cements have different requirements of water to produce the limiting values of shear. The maximum and minimum values of the slope and intercept are respectively as follows:

2.63, 7.43, and 0.065, 3.65.

SYNTHESIS OF KAOLINITE AND DICKITE.

An error occurs in this item on page 18 of the Technical News Bulletin No. 190; February, 1933. The second paragraph, tenth line should read: "$Al_2O_3.2SiO_2.2H_2O$ are 39.5 per cent."

NEW LIST OF STANDARD SAMPLES.

A new list of standard samples for use in chemical analyses has just been published by the bureau as Supplement to Circular No. 398. This replaces the former list known as Supplement to Circular No. 25.

The samples are listed by groups, such as irons and steels, ferro alloys, sheet brass, bronzes, bearing metals, die-casting alloys, limestone, clays, glass sand, various kinds of glasses and ores; sugar, naphthalene and benzoic acid for determining heats of combustion; cement for testing the fineness of sieves; and pure chemicals, such as sodium oxalate, arsenic trioxide, and acid potassium phthalate.

Directions are given for ordering and the methods of shipment to addresses in the United States and foreign countries are described.

Copies of this pamphlet are obtainable without charge from the Bureau of Standards, Washington, D. C.

NOTES FROM THE BARTOL RESEARCH FOUNDATION OF THE FRANKLIN INSTITUTE.

THE MASSES OF Ne^{20} AND B^{11}. THE MASS OF Ne^{22} AND THE DISINTEGRATION OF F^{19}.*

BY

K. T. BAINBRIDGE.

[Abstract.]

The mass of B^{11} was measured as 11.0107 ± 0.001, a figure in good agreement with Aston's determination.

The value obtained for the mass of Ne^{20}, 19.9967 ± 0.0009 is outside of the limit of error of Aston's determination 20.0004 ± 0.002. It is suggested that the high value obtained by Aston may be traced to the experimental conditions. Aston measured the mass of Ne^{20} from the approximate ratios $Ne^{20} : O :: CH_3 : C$. If the resolving power of the apparatus was below par at the time, the unavoidable presence of CH_4 might serve to depress the position of the O line and so increase the measured value of Ne^{20}. A shift in the position of O of 0.003 to 0.005 cm from this cause could account for the difference in the masses of Ne^{20} as measured on the two different spectrographs. The value obtained for the mass of Ne^{22} by means of the mass-spectrograph was 21.9947 ± 0.0009. Aston has reported the provisional value 22.0048.

The mass of Ne^{22} is of particular interest as the experiments of Rutherford and Chadwick, and Chadwick, Constable and Pollard indicate that the disintegration of F^{19} by α-particle impact results in the emission of a proton and the formation of Ne^{22}. The mass of Ne^{22} calculated on this basis from the known energy changes in the disintegration gives a figure 21.9925 ± 0.0015 for the maximum mass of Ne^{22}. If the two million electron-volt γ rays observed by Webster are attributed

* This paper, in its entirety, was published in the *Physical Review*, March 15, 1933.

to Ne^{22} the mass 21.9925 must be decreased to 21.9903. Consequently on the basis of the disintegration experiments and the mass of F^{19} the mass of Ne^{22} cannot exceed 21.9925 $\pm$ 0.0015. The agreement between the measured mass and the calculated mass is not satisfactory.

An explanation which has the benefit of agreement with the chemical data is that the mass spectrograph value of F^{19} may be low. Further work will be necessary before the question can be settled.

THE MASS OF Be^9 AND THE ATOMIC WEIGHT OF BERYLLIUM.*

BY

K. T. BAINBRIDGE.

The mass of Be^9 was measured from five spectra as 9.0155 $\pm$ 0.0006 units on the $O^{16} = 16$ scale. Be^{9+} was compared with C^{12+} by means of the ratios $Be^{9+} : C^{12+} : : C^{12+} : CH_4^+$. The mass of Be^9 was also compared with that of Ne^{20++} by use of the approximate ratios $Be^{9+} : Ne^{20++} : : C^+ : CH^+$. The value obtained from five spectra using this latter ratio was 9.0154 $\pm$ 0.0008 when referred to $Ne^{20} = 19.9967$.[1] The other reference masses were $C^{12} = 12.0036$ and $H^1 = 1.00778$ as given by Aston.[2] Attempts to measure the mass of Be^9 by the ratios $Be^{9+} : O^{++} : : OH_2^+ : O^+$ have not succeeded so far as oxygen appears to be "cleaned up" in the presence of the $BeCl_2$ used to provide the beryllium ions. Except for the runs in which oxygen was present a satisfactory source of Be ions was provided by the evaporation from the cathode of anhydrous $BeCl_2$ with subsequent ionization in a discharge run in neon. This type of source has been described before.[3]

There are several interesting considerations which follow from this determination of the mass of Be^9.

1. It appears improbable that the nucleus of Be^9 consists of two α-particles and one neutron [4] or of two α-particles and

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* This note was published in the Physical Review, March 1st 1933.

[1] K. T. Bainbridge, *Phys. Rev.*, 43, issue of March 15, 1933. Paper presented before American Physical Society, Dec. 28, 1932.

[2] F. W. Aston, *Proc. Roy. Soc.*, 115, 487 (1927).

[3] K. T. Bainbridge, *Phys. Rev.*, 39, 847, 1021 (1932).

[4] F. Perrin, *C. R.*, 194, 1343 (1932).

one proton and one electron as the sum of the masses of the suggested components is less than the mass of the stable Be^9 nucleus.

2. Allowing for the presence of one part in 2000 of Be^8,[5] the atomic weight of beryllium on the chemical scale is 9.0130 ± 0.0007, which is considerably lower than the value 9.0179 ± 0.0009 which Hönigschmid and Birkenbach [6] obtained by chemical means.

3. The packing fraction of Be^9 is $+ 17.2$ which is located well off the packing fraction "curve" for elements of even atomic number.

4. Curie and Joliot [7] have calculated the mass of Be^9 and obtained a value 9.0109 on the $O^{16} = 16$ scale under the assumptions that $Be^9 + \alpha \rightarrow C^{12} +$ neutron, that the energy of the neutron is 7.8×10^6 electron-volts, that no γ-rays are emitted in the process of disintegration, and that the Be neutrons have the same mass as the B neutrons. On the other hand the work of Meitner and Philipp [8] and of Rasetti [9] in conjunction with that of Becker and Bothe [10] strongly indicates that γ-rays do accompany the emission of neutrons from beryllium when it is bombarded by α-particles. Taking the process of disintegration to be $Be^9 + \alpha \rightarrow C^{12} +$ neutron $+ \eta\nu$ and the mass of Be^9 to be 9.0155 and the mass [11] of the

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[5] W. W. Watson and Allan E. Parker, *Phys. Rev.*, **37**, 167 (1931).

[6] O. Honigschmid and L. Birkenbach, *Ber. Chem. Ges.*, **55B**, 4 (1922). The atomic weight of beryllium from the ratio $BeCl_2/Ag$ is given as 9.0179 with a "mean error" $\pm$ 0.0013.

[7] I. Curie and F. Joliot, *Nature*, **130**, 57 (1932); I. Curie, F. Joliot and P. Savel, *C. R.*, **194**, 2208 (1932).

[8] L. Meitner and K. Philipp, *Naturwiss.*, 20, 929 (1932).

[9] F. Rasetti, *Zeits. f. Physik*, **78**, 165 (1932).

[10] H. Becker and W. Bothe, *Zeits. f. Physik*, **76**, 421 (1932).

[11] J. Chadwick, *Proc. Roy. Soc.*, **136**, 692 (1932). The mass of the neutron is 1.0067 ± 0.0010 from Chadwick's disintegration data and Aston's mass values for N^{14}, B^{11} and He^4 (reference 2). The probable error has been calculated here in the customary manner on the basis that Aston's limits of error are equal to three times the probable errors of his measurements. Two other sets of data permit an upper and a lower limit to be placed on the mass of a neutron assuming the existence of only one type of neutron.

The emission of neutrons by the process $Li^7 + \alpha \rightarrow B^{10} + \eta$ gives an *upper limit* for the mass of a neutron 1.0063 ± 0.0008 from the mass data of J. Costa (*Ann. de Physique*, **4**, 425 (1925) and F. W. Aston (reference 2) and the disintegra-

neutron 1.0067, 12.1 × 10^6 electron-volts are available for the energies of the neutron and γ-ray. Under this mode of disintegration 7.8 × 10^6 electron-volt neutrons[7] might be accompanied by 4.3 × 10^6 electron-volt γ-quanta. It is an open question whether the γ-rays found experimentally,[12] are produced as a primary process in the disintegration of the beryllium or whether, as indicated in the recent experiments of Auger,[13] the γ-rays are produced by a secondary process as a result of inelastic neutron impacts in nearby materials. The production of γ-rays by both processes may of course take place concurrently.

5. Sufficient energy is available from the combination $Be^9 + \alpha + E\alpha$ so that a large number of disintegration mechanisms are theoretically possible. The evidence available at present is best satisfied by the reaction $Be^9 + \alpha \rightarrow C^{12}$ + neutron + $\eta\nu$. The experiments which have been performed up to the present time have not been such as to eliminate alternative modes of disintegration. One such possible mechanism, for example, might be $Be^9 + \alpha \rightarrow 3\alpha$ + neutron + $\eta\nu$, which might be a "capture" or a "non-capture" process.

Although the measured mass of Be^9 cannot be used at present for an evaluation of the mass of the neutron, it is hoped that this Be^9 mass determination may help ultimately in the solution of the questions attendant on the disintegration of beryllium by different agents.

The author wishes to take this opportunity to thank Dr. A. Bramley for the benefit of his criticisms, discussions, and interest; Dr. W. F. G. Swann for his interest and support and Professor John A. Miller and Dr. M. Kovalenko of the Swarthmore College Observatory for their generous permission to use their measuring instruments.

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tion experiments of I. Curie, F. Joliot and P. Savel (reference 7) and M. deBroglie and L. Leprince-Ringuet (*C. R.*, **194**, 1616, 1932).

If the nucleus of H^3 is composed of one proton and one neutron, 1.0057 ± 0.0002 is a *lower limit* for the mass of a neutron (K. Bainbridge, *Phys. Rev.*, **41**, 115 (1932)).

[12] Wilson chamber β-ray tracks in a magnetic field, I. Curie and F. Joliot, *C. R.*, **194**, 708, 1229 (1932). P. Auger, ibid., 877. By absorption and coincidence method, H. Becker and W. Bothe, *Naturwiss.*, **20**, 757 (1932) and Reference 10; F. Rasetti, *Naturwiss.*, **20**, 252 (1932).

[13] P. Auger, *C. R.*, **196**, 170 (1933).

THE FRANKLIN INSTITUTE.

STATED MONTHLY MEETING, MARCH 15, 1933.

The regular monthly meeting of the Institute was called to order at eight-fifteen P.M. by the President, Mr. Nathan Hayward.

He announced that the Secretary had one or two items of business to present and called upon the latter for a report.

The Secretary stated that it was the custom of the Institute to elect to Honorary Membership all persons to whom Franklin Medals had been awarded. He added that, in accordance with this practice, the Board of Managers recommended the election of Dr. Paul Sabatier, Dean of the Faculty of Sciences, Toulouse University, France, "in recognition of his fundamental contributions to our knowledge of catalysis"; and of Dr. Orville Wright, Dayton, Ohio, "because of the pioneer contributions of himself and his brother Wilbur to the science of aviation and the invention of the first heavier-than-air machine flown by its own power under human control."

It was thereupon voted unanimously by the meeting to elect these two gentlemen to Honorary Membership in The Franklin Institute.

The Secretary further announced that sixty days ago, in accordance with the requirement of the By-laws of the Institute, the Committee on Membership issued notice that, at the meeting of tonight, the Committee would propose the necessary amendments to the By-laws in order to establish a new class of membership in the Institute, to be known as "Family Membership."

Acting for the Membership Committee and with the approval of the Board of Managers, the Secretary moved the adoption of the following amendments to the By-laws:

That Article II, Section 9, be amended to read as follows:

Family Membership shall include parents of the household, both or either, all children dependent upon and resident with them, and all female relatives of the family living permanently in the same house as the heads of the household. Separate membership tickets shall be issued for all members of the family as designated by the head of the family. The fee for family membership shall be twenty dollars per year but shall not carry with it the receiving of the JOURNAL OF THE FRANKLIN INSTITUTE. However, Family Membership may include one subscription for the JOURNAL upon the payment of an additional five dollars, or twenty-five dollars in all.

That Article II, Section 9, entitled "Privileges," be amended to read:

Article II, Section 10, *Privileges.* All members of whatever class are entitled to participate in the meetings of the Institute and in the use of the library, to receive tickets for the lectures and to receive monthly one copy of the JOURNAL of the Institute, except that Student members and Honorary and Corresponding members and Family members shall not have the right to vote nor to hold office, and Student members paying the three dollars annual dues, and the Family members paying the twenty dollars annual dues, shall not receive the JOURNAL of the Institute.

That an additional Section, under Article II, to be known as Section 11, reading as follows, be adopted:

Section 11. Membership tickets in the Institute shall be issued to all members of whatever class. Such membership tickets will admit their proper holders to all parts of The Franklin Memorial and The Franklin Institute Museum at all times when the various sections of the building are open to the public.

These three motions were then voted unanimously. The President declared the three amendments to the By-laws adopted.

As there was no further business the President presented the lecturer of the evening, Dr. Frederick Ehrenfeld, Professor of Geology and Mineralogy, University of Pennsylvania, who spoke on "The Riddle of the Earth: Efforts to Read It."

The lecture was delightfully given and was heard by an audience which crowded the lecture hall. The talk was followed by a somewhat animated discussion, after which the meeting was adjourned by a statement of appreciation of the lecturer's efforts and delightful results.

The meeting adjourned at nine-forty-three o'clock.

HOWARD MCCLENAHAN,
Secretary.

COMMITTEE ON SCIENCE AND THE ARTS.

(*Abstract of Proceedings of Stated Meeting held Wednesday, March 8, 1933.*)

HALL OF THE COMMITTEE,
PHILADELPHIA, MARCH 8, 1933.

MR. T. F. CLARK *in the Chair.*

The following report was presented for final action:

No. 2967: Literature.

This report recommended the award of the Louis Edward Levy Medal to Mr. Leon S. Moisseiff, of New York City, for his paper entitled "The Design, Materials and Erection of the Kill Van Kull (Bayonne) Arch," published in the May, 1932 issue of the Institute's JOURNAL.

The following reports were presented for first reading:

No. 2961: Photo-Flash Lamp.

No. 2969: New Methods in Astronomical Photography.

GEO. A. HOADLEY,
Secretary to Committee.

MEMBERSHIP NOTES.

ELECTIONS TO MEMBERSHIP.

(*Stated Meeting, Board of Managers, March 15, 1933.*)

Elections.

RESIDENT.

MISS ELLEN JARDEN NOLDIE, 7602 East Lane, Chestnut Hill, Philadelphia, Pa.

CHANGES OF ADDRESS.

DR. DONALD S. ASHBROOK, University Club, Sixteenth and Locust Streets, Philadelphia, Pa.

PROFESSOR ARTHUR W. GOODSPEED, 4623 Sansom Street, Philadelphia, Pa.

MR. E. J. HOCHREITER, 525 West Clapier Street, Germantown, Philadelphia, Pa.

MR. M. C. KENNEDY, Chambersburg, Pa.

MR. J. VAUGHAN MERRICK, The Philadelphia Club, Thirteenth and Walnut Streets, Philadelphia, Pa.

DR. FRANCIS D. PATTERSON, P. O. Box 4061, West Philadelphia Station, Philadelphia, Pa.

DR. WILLIAM ROGERS, JR., 300 Chandler Street, Philadelphia, Pa.

MR. SAMUEL SPITZ, 365 South Cloverdale Avenue, Station C, Los Angeles, Cal.

MR. S. WEINBERG, Gimbel Building, 6th Floor, Eighth and Market Streets, Philadelphia, Pa.

MR. JOHN H. WIDMYER, 150 East King Street, Lancaster, Pa.

NECROLOGY.

Mr. John J. L. Houston, Philadelphia, Pa.
Dr. F. N. Pease, Altoona, Pa.
Mr. Charles S. Wurts, Jr., Philadelphia, Pa.
Mr. H. W. York, New York City, N. Y.

LIBRARY NOTES.

RECENT ADDITIONS.

BOHR, NIELS. La Théorie Atomique et la Description des Phénomènes. Traduction française. 1932.

Brassey's Naval and Shipping Annual, 1933. Edited by Commander Charles N. Robinson, R.N., and H. M. Ross. Forty-fourth Year of Publication.

BROWN, HUGH A. Radio Frequency Electrical Measurements. 1931.

Chemiker-Kalender, 1933. Ein Hilfsbuch für Chemiker, Physiker, Mineralogen, Industrielle, Pharmaceuten, Hüttenmänner, usw. In drei Teilen. Vier und fünfzigster Jahrgang. 1933.

KOLTHOFF, I. M., AND N. HOWELL FURMAN. Potentiometric Titrations: a Theoretical and Practical Treatise. Second edition, extensively revised. 1931.

LAUER, HENRI, AND HARRY L. BROWN. Radio Engineering Principles. Second edition. 1928.

MAGEE, JAMES F. An American Student Abroad, from the Letters of James F. Magee. Edited by George W. Magee, Jr. 1932.

OWER, E. Some Aspects of the Mutual Interference between Parts of Aircraft. Aeronautical Research Committee Reports and Memoranda No. 1480. 1932.

PRIME, ALFRED COXE. The Arts and Crafts in Philadelphia, Maryland and South Carolina 1786–1800. Series Two. Gleanings from Newspapers. 1932.

Standard Handbook for Electrical Engineers. Prepared by a Staff of Specialists. Frank F. Fowle, Editor-in-Chief. Sixth edition, thoroughly revised and enlarged. 1933.

THOMSON, SIR J. J., AND G. P. THOMSON. Conduction of Electricity through Gases. Third edition. Volume 2: Ionisation by Collision and the Gaseous Discharge. 1933.

TURNBOW, GROVER DEAN, AND LLOYD ANDREW RAFFETTO. Ice Cream: a Textbook for Student and Manufacturer. 1928.

BOOK REVIEWS.

MIRRORS, PRISMS AND LENSES, A TEXT-BOOK ON GEOMETRICAL OPTICS. By James P. C. Southall, Professor of Physics, Columbia University, author of the Principles and Methods of Geometric Optics. 3d edition, xxiv–806 pages, 13.5 × 19.8 cms., cloth. New York, The Macmillan Company, 1933. Price $4.50.

Until comparatively recent years, geometrical optics was not especially stressed in technical school curricula, and in so far as providing more than an outline of the simpler theorems of the subject, there were no text-books available which contained information that made contact with the principles of design of optical apparatus. It is not that analytical material was wanting; there was much of it adapted to modern use, as note the famous old book by Henry Coddington, "A Treatise on the Reflection and Refraction of Light" which was published in England in 1829. Old as it is, that book with little refurbishing might well serve as a model for a modern text. The true reason for the growth of interest in applicable optical theory is doubtless the rapid strides which the industry has made in this country in recent years. Optical scholars have met the intellectual reaction to this movement by a gradually accelerated rate of production of text-books of a scope and character that harmonize with actual production requirements.

The author's book may claim a handsome share in these contributions. It provides a didactic text which covers the elements of the subject of reflection and refraction, for students who intend to apply it eventually to professional use, with a degree of thoroughness which is unique. The work deals mainly with first order approximations, the usual paraxial ray formulas, but with a degree of amplification that will satisfy all reasonable desire for exhaustive treatment. It may be noted that considerable stress is laid upon optometrical practice so that, coupled with its broad scope, the book will be highly appreciated in that field.

Geometrical constructions abound but not without demonstrations; the author digresses amply in the geometry of perspective ranges of points and the special case of harmonic range and its application to the reflection of a paraxial ray at a spherical mirror. Further along, with the consideration of three-color composition more geometry is provided on a form of trilinear coördinates. It is simple to follow by elementary geometry though captioned by the formidable name "homogeneous projective coördinates." However, it may be pointed out, in no part of the book is the reader required to use other mathematics than plane geometry, a little algebra and a bit of plane trigonometry. So the reader's chief concern will

be in following the true significance and limitations of the formulas which are derived and an accurate understanding of the phenomena which they represent. In its helpful character in clarifying such difficulties may be commended the large number of appropriately chosen examples as well as the uniform lucidity and ample length of explanatory matter.

In a subject like this one whose topics are more or less interdependent one may easily err in attempting to point out those of capital interest, but the tracing of a paraxial ray through a centered optical system is safely enough a process whose elucidation, will command deep interest on the part of the reader. Again the discussion on aperture stop and the pupils, important elements in an optical system is given at considerable length. The final pages contain chapters on dispersion and achromatism, an outline of the aberration of rays of finite slope, historical notes, the microscope and other visual instruments, ophthalmic data, color theory and an examination into the nature of light.

The work is now in its third edition, and its obvious appeal to anyone seeking worth-while optical information bespeaks for it a life of many more editions.

L. E. P.

OUR MINERAL CIVILIZATION, by Thomas T. Read, E.M., Ph.D., 164 pages, 13 × 19 cms. Baltimore, The Williams and Wilkins Company, 1932. Price $1.00.

This little volume anticipates its wisdom by the questions on the inside tuck of the front jacket.

Do you know:—

That the Chinese drilled wells over 3000 feet as long ago as the middle ages?

That a mineral element gives man's eyes mastery over time and space?

And so on and so forth! The happy way in which Dr. Read has presented innumerable useful facts will well repay the reading by anyone with only an ounce of curiosity about the mineral foundation of our world. There is spread out before the reader the magic carpet of present-day industry. The skeleton of modern structures is linned against the sky—iron and steel, with its intimates coal and oil.

The three sons of vulcan give one an inkling of the imaginative quality of the Greeks as well as the imaginative quality of Prof. Read when treating with such useful metals as copper, lead and zinc. After which he introduces many other "humble servants," marble, cement, talc, fluorspar, asbestos, graphite, mica and salt. Each one conjures its own mental picture. The marble of Phidias, the cement of the new High School on Spring Garden Street, the talc of milady's compact, fluorspar of endless tariff debate, asbestos of the squealing brakes, the graphite of our bicycle days, the mica of the stove door and who can resist the lure of salt on a generous wedge of truncated shad.

Junior metals and many mighty midgets remind a careless world of our dependance on tungsten when we light the light, radium if we face death from cancer, neon if the signs of Sansom Street are to induce us to cash our old gold, and selenium if we suffer the handicap of the blind and carry a selenium cell. This strange metal converts light into sound so that the windows and doors and sunsets bring light to the eyes of the mind thanks to its characteristic of passing an electric current when under the influence of light.

There are some books which one hates to lose but the loss is not a matter of perpetual mourning. Other books when lost must be replaced. It so happened that "Our Mineral Civilization" left me in the subway and I found it imperative to pester the Lost and Found to retrieve my treasure. I had no success so in spite of the depression, I purchased another copy. My hope is that the lucky pirate who found the first book will forego his evil ways and become a metallurgist.

H. W. ELKINTON.

ELECTRIC AND MAGNETIC FIELDS. By Stephen Atwood, Assistant Professor in Electrical Engineering, University of Michigan. xi-314 pages, diagrams, tables, 14 × 23 cms., cloth. New York, John Wiley & Sons, Inc., 1932. Price $3.50.

Electric and magnetic fields, particularly the former, are not generally treated at any great length in texts on electricity and magnetism. In this book the field of force is the major topic, a logical mode of approach to the other topics of electricity and magnetism. Explaining the general arrangement, the author says: "The book is divided into four parts. The electric field is discussed in the first part. Because of its relative simplicity compared with the magnetic field, the electric field is better adapted to the purpose of developing the field concepts of potential, field intensity, flux density, etc. Moreover, such a large part of the electrical engineering curriculum deals with magnetic relations that the electric field is often neglected. The electric field deserves the emphasis that it receives in being discussed first.

"The magnetic field is treated in the second part, where the field formulae are developed under the assumption of constant permeability. The ferro-magnetic field, in the third part, introduces the modifications of the basic magnetic relations necessary to account for the use of magnetic material in which permeability cannot be considered constant. It is believed that this division in the study of magnetism aids the student to a considerable degree in obtaining a clearer interpretation of the fundamental relations. The fourth part, combined electric and magnetic fields, develops the relations between the various systems of units that have been used and treats in an elementary manner the interactions between electric and magnetic fields that simultaneously occupy the same space."

Prominent features of the text are the beautifully executed drawings and sketches of electric and magnetic fields, and "field mapping" which the author points out can be a successful substitute for the higher forms of mathematics. The clarity of the text and ample detail with which the analytical procedures are carried out leave nothing to be desired. A generous collection of problems accompanies each chapter. Neither are answers given to these problems nor are any worked-out problems included in the text. Opinions differ on how much aid of that kind a student should receive. To readers who are studying alone and unaided, such help is most welcome and legitimate. An historical outline is given in an appendix.

Though not a few books develop the subject on the basis of current-flow, the field point of view is the admittedly logical basis upon which the author has developed a text of high order of excellence. The typography and general execution of the volume are of equally high order.

L. E. P.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS:

Report No. 448—Improved Apparatus for the Measurement of Fluctuations of Air Speed in Turbulent Flow—by W. C. Mock, Jr., and H. L. Dryden, 26 pages, illustrations, tables, 23 × 29 cms. Washington, Superintendent of Documents, 1932. Price ten cents.

This report describes recent improvements in the design of the equipment associated with the hot-wire anemometer for the measurement of fluctuating air speeds in turbulent air flow, and presents the results of some experimental investigations dealing with the response of the hot wire to speed fluctuations of various frequencies. Attempts at measuring the frequency of the fluctuations encountered in the Bureau of Standards' 54-inch wind tunnel are also reported. The design of the amplifying and compensating equipment for use with the hot wire is treated briefly. In addition, the difficulties encountered in the use of such apparatus and the precautions found helpful in avoiding them are discussed. The work was carried out at the Bureau of Standards with the coöperation and financial support of the National Advisory Committee for Aeronautics.

Report No. 449—Wing Characteristics as Affected by Protuberances of Short Span—by Eastman N. Jacobs and Albert Sherman, 10 pages, illustrations, 23×29 cms. Washington, Superintendent of Documents, 1933. Price five cents.

The drag and interference caused by short-span protuberances from the surface of an airfoil have been investigated in the N. A. C. A. variable-density wind tunnel at a Reynolds Number of approximately 3,100,000, based on the chord length of the airfoil. The effects of variations of the protuberance span length, span position, and shape were measured by determining how the wing characteristics were affected by the addition of the various protuberances.

The results indicate that the central sections of a rectangular wing are more sensitive to the addition of protuberances than the outer sections. A very short protuberance in the midspan position may cause a disproportionately large reduction in maximum lift. At low values of the lift coefficient the drag due to the protuberances increases approximately as the total length for protuberances of equal height, but at higher lift coefficients induced interference effects appear so that short-span protuberances produce disproportionately large drag increases. An example is included to show how airfoil theory and a knowledge of the section characteristics may be applied to estimate induced interference effects. The adverse effects of protuberances are shown to be greatly reduced by simple fairings.

AMATEUR TELESCOPE MAKING. Edited by A. G. Ingalls, Associate Editor, *The Scientific American*, XII–500 pages, with numerous plates and figures. 15 x 20 cms., Scientific American Publishing Company, 1933. Price $3.00.

When Russell W. Porter, former Arctic explorer, architect and optician, joined the staff of the Jones and Lamson Machine Company in Springfield, Vermont, after the War as "optical associate," there was a mere handful of amateur astronomers in the United States who had made their own telescopes. Mr. Porter had already made several and about 1922 he interested a group of his fellow-employees in making them also. Thus arose the Amateur Telescope Makers of Springfield, the parent society of a number of others in such widely

scattered places as Los Angeles, Tacoma, Chicago and Pittsburgh. In addition, probably several thousand amateurs not connected with these societies have built their own telescopes with which to make a better acquaintance of the starry skies.

The book under review, now in its third edition, is the reason for this great spread of an interesting pursuit. It was in 1925 that the *Scientific American* published a brief article by Mr. Ingalls on the subject, which was followed by several others by Mr. Porter, giving the elements of the subject. At that time there was only one book giving the information on telescope making. This was *The Amateur's Telescope*, by the Reverend W. F. A. Ellison, Director of the Armagh Observatory in Northern Ireland, a work not easily accessible in the United States. *The Scientific American* articles and the bulk of Ellison's book were published in 1926 in a modest little volume of 102 pages, the first edition of the present work. Though an edition of 2,400 copies was printed, these had all been sold by 1928. A new edition of 5,400 copies of the work, enlarged to 285 pages, appeared in 1928, but this was exhausted in 1932. Now, in the third edition, it has grown to the respectable size of 500 pages, including a carefully prepared index, which greatly enhances the value of the book.

Several prominent names appear among the twelve contributors who, in addition to Mr. Ingalls, have written sections for the book. The fundamentals of mirror making, for by far the most popular amateur telescope is the reflector, are still given by Mr. Porter, who is now Associate in Optics at the California Institute of Technology, working on the 200-inch telescope project. The late Professor Charles S. Hastings, of Yale University, contributes an article on telescope eyepieces. The Reverend Mr. Ellison's useful instructions are still retained. Numerous descriptions of typical amateur telescopes, ranging from simple wooden mountings to elaborate clock driven equatorials, of which any professional maker might be proud, are given by John M. Pierce, Springfield, Vermont; Clarendon Ions, Washington, D. C., and others.

Intentionally, the giving of exact working drawings is avoided, since the amateur generally wants to incorporate his own ideas and any effort at standardization is likely to defeat its own object by causing him to lose interest.

It is interesting to note that the usual modern method of figuring the mirror, by grinding two discs of glass together, the lower one assuming a convex shape, and the upper (which becomes the final mirror) concave, was discovered independently by Dr. Elihu Thomson, and described in the JOURNAL OF THE FRANKLIN INSTITUTE, in 1878. But, in addition to knowing how to grind the mirror, the amateur must know how to test it, and full practical directions are given for the Foucault test and several modifications, thereof.

With so many amateurs having made one or more reflecting telescopes, there are some who seek new worlds to conquer, and chiefly for their benefit, there are included such advanced topics as the construction of refractors, the construction and use of grinding machines, and an article by Dr. George Ellery Hale, founder and honorary director of the Mt. Wilson Observatory, telling how to make and use a spectrohelioscope and a simple spectroheliograph. Nor are the uses of the telescopes themselves in observing the heavens neglected, for it is a great waste to astronomy to have so many telescopes made and so few used for productive work. Despite the wonderful advances that astronomy has made in recent years, with the giant telescopes of the great observatories, there is still plenty of useful work possible for the amateur with his modest equipment.

In the new Franklin Institute Museum there will be a department for the use of the amateur astronomers and telescope makers to whom this book will be an indispensable vade mecum. To all who want to get acquainted with this fascinating hobby, it can be confidently recommended, and to those who have profited by the earlier editions, this new one, with valuable additional material added, will be doubly welcome.

JAMES STOKLEY.

PUBLICATIONS RECEIVED.

Time, Space and Atoms, by Richard T. Cox, 154 pages, illustrations, 12.5 × 19 cms. Baltimore, Williams and Wilkins Company, 1933. Price $1.00.

The Story of a Billion Years, by William O. Hotchkiss, 137 pages, illustrations, 12.5 × 19 cms. Baltimore, Williams and Wilkins Company, 1932. Price $1.00.

Chemistry Triumphant, by William J. Hale, 151 pages, illustrations, 12.5 × 19 cms. Baltimore, Williams and Wilkins Company, 1932. Price $1.00.

Amateur Telescope Making, edited by Albert G. Ingalls, 500 pages, illustrations, tables, 14 × 19.8 cms. New York, Scientific American Publishing Co., 1933. Price $3.00.

Chemical Wave Transmission in Nerve, by A. V. Hill, 74 pages, illustrations, 14 × 22.3 cms. New York, The Macmillan Company, 1932. Price $1.25.

Elementary Laboratory Experiments in Organic Chemistry, by Roger Adams and John R. Johnson, 363 pages, tables, illustrations, 14.5 × 22 cms. New York, The Macmillan Company, 1933. Price $1.90.

Heat and Its Workings, by Morton Mott-Smith, 239 pages, illustrations, 13 × 19 cms. New York, D. Appleton & Company, 1933. Price $2.00.

Actualités Scientifiques et Industrielles, Exposés de Morphologie Dynamique, II, Probabilités et Morphologie, par A. Sainte-Laguë, 29 pages, illustrations, 16.5 × 25.5 cms. Price 6 francs. Exposés sur la Théorie des Quanta, I, Notions de Mécanique Ondulatoire les Méthodes d'Approximation, par L. Brillouin, 34 pages, illustrations, 16.5 × 25.5 cms. Price 10 francs. Centre International de Synthése, I, Critique des Notions d'Éther d'Espace et de Temps Cinématique de la Relativité, par E. Bauer, 29 pages, 16.5 × 25.5 cms. Price 7 francs. II, La Dynamique Relativiste et l'Inertie de l'Energie, par Francis Perrin, 19 pages, 16.5 × 25.5 cms. Price 6 francs. III, Conséquences de la Relativité dans le Developpement de la Mécanique Ondulatoire, par Louis de Broglie, 12 pages, 16.5 × 25.5 cms. Price 6 francs. IV, La Théorie Einsteinienne de la Gravitation les Verifications Expérimentales, par G. Darmois, 30 pages, 16.5 × 25.5 cms. Price 7 francs. V, Le Parallélisme Absolu et la Théorie Unitaire du Champ, par Elie Cartan, 21 pages, 16.5 × 25.5 cms. Price 6 francs. VI, La Relativité Conclusion Générale, par Paul Langevin, 17 pages, 16.5 × 25.5 cms. Price 6 francs. Paris, Hermann et Cie, 1932.

Données Numeriques de Photographie, redigées par Dr. W. Clark et L.-P. Clerc, 52 pages, 22 × 28 cms. Paris, Gauthier-Villars et Cie, 1932.

National Advisory Committee for Aeronautics, Technical Notes, No. 446, Estimation of the Variation of Thrust Horsepower with Air Speed, by Shatswell Ober, 6 pages, 20 × 26 cms. Washington, Committee, 1933. No. 447, The

Effect on Lift, Drag, and Spinning Characteristics of Sharp Leading Edges on Airplane Wings, by Fred E. Weick and Nathan F. Scudder, 15 pages, illustrations, tables, 20 × 26 cms. Washington, Committee, 1933. No. 448, Effect of Aileron Displacement on Wing Characteristics, by R. H. Heald, 10 pages, tables, illustrations, 20 × 26 cms. Washington, Committee, 1933. No. 449, Wind-Tunnel Research Comparing Lateral Control Devices, Particularly at High Angles of Attack. IX. Tapered Wings with Ordinary Ailerons, by Fred E. Weick and Carl J. Wenzinger, 14 pages, tables, illustrations, 20 × 26 cms. Washington, Committee, 1933. No. 450, Mercerization of Cotton for Strength with Special Reference to Aircraft Cloth, by J. B. Wilkie, 16 pages, illustrations, tables, 20 × 26 cms. Washington, Committee, 1933. No. 451, Wind-Tunnel Research Comparing Lateral Control Devices, Particularly at High Angles of Attack. X. Various Control Devices on a Wing with a Fixed Auxiliary Airfoil, by Fred E. Weick and Richard W. Noyes, 18 pages, tables, illustrations, 20 × 26 cms. Washington, Committee, 1933. No. 452, The Importance of Auto-Ignition Lag in Knocking, by E. S. Taylor, 7 pages, diagrams, 20 × 26 cms. Washington, Committee, 1933.

CURRENT TOPICS.

Radium-Water Generators.—HERMAN SCHLUNDT, RALPH G. FULTON, AND FRANK BRUNER (*Jour. of Chem. Ed.*, 1933, X, 185–187) have determined the quantities of radon and of radium actually present in the water obtained from three representative radium-water generators which were operated as directed by the manufacturers. They conclude that steady drinkers of such water are not in danger of radium poisoning. "The alleged therapeutic value of slightly radio-active waters probably rests more on the larger daily doses of water drunk than on the radon contained therein.

J. S. H.

Glucosone.—This organic compound is a derivative of glucose and contains both an aldehyde group and a ketone group. KENDAL CARTWRIGHT DIXON AND KENNETH HARRISON (*Biochem. Jour.*, 1932, XXVI, 1954–1958) have devised a new method for its preparation by the oxidation of fructose in aqueous solution by means of selenious acid at the temperature of boiling water. Their researches have failed to reveal any evidence of the formation of glucosone in the animal body as a product of metabolism.

J. S. H.

Synthesis of Tartaric Acid.—A. C. C. NEWMAN AND H. L. RILEY (*Jour. Chem. Soc.*, 1933, 45–46) have obtained racemic tartaric acid by synthesis from glyoxal. The bisbisulphite of glyoxal and potassium cyanide reacted to form the dicyanhydrin which was hydrolyzed by boiling for 12 hours beneath a reflux condenser, after saturation of the solution with hydrogen chloride. The racemic acid was isolated as its calcium salt. The yield was 30 per cent.

J. S. H.

Stability of Vitamin A in Cod Liver Oil Emulsions.—H. N. GRIFFITHS, T. P. HILDITCH, AND J. RAE (*Analyst*, 1933, LVIII, 65–68) have tested five samples of cod liver oil emulsion, at intervals, for their vitamin A content. For at least 4 months, none of the emulsions showed any appreciable loss in vitamin A potency as compared with the original oil. At 6 or 7 months, some evidence of change appeared; and, at 15 months, the decline in vitamin content was quite definite. Such emulsions should be kept in well stoppered bottles of amber glass, in a dark place; their vitamin A content will

not be appreciably altered for at least 4 months, and will not be seriously depleted for probably 7 or 8 months.

J. S. H.

New Source of Capric Acid.—C. R. NOLLER, I. J. MILLNER, AND J. J. GORDON (*Jour. Am. Chem. Soc.*, 1933, LV, 1227–1228) have analyzed the seed fat of the California bay tree (*Umbellularia californica*) and found that the fatty acids present include approximately 1 per cent. caprylic acid, 37 per cent. capric acid, and 62 per cent. lauric acid. This fat is by far the best source of caprice acid, $C_9H_{19}COOH$.

J. S. H.

Sulphur Compounds Derived from Petroleum.—P. J. WIEZEVICH, L. B. TURNER, AND PER K. FROLICH (*Ind. Eng. Chem., Ind.* Ed., 1933, XXV, 259–296) state that the following groups of sulphur compounds are by-products of the refining of crude petroleum: Mercaptans, thioethers, disulphides, sulphoxides, sulphones, sulphonic acids, and polysulphides.

J. S. H.

Derivation of the Names of the Chemical Elements.—SAUL S. HAUBEN (*Jour. Chem. Ed.*, 1933, X, 227–234) gives an alphabetic list of the chemical elements, with a short account of the derivation of the name of each element.

J. S. H.

Occurrence of Laevo Galactose in Flaxseed Mucilage.—The common form of the sugar galactose is dextro galactose which is present in lactose or milk sugar. ERNEST ANDERSON (*Jour. Biol. Chem.*, 1933, C, 249–253) has prepared pure laevo galactose (the optical antipode of dextro galactose) from both flaxseed mucilage and flaxseed itself. The seed contains approximately one-third per cent. of laevo galactose, the mucilage approximately 11 per cent.

J. S. H.

Resolution of Racemic Tryptophane into its Optically Active Constituents.—CLARENCE P. BERG (*Jour. Biol. Chem.*, 1933, C, 78–83) has isolated dextro tryptophane and laevo tryptophane from racemic tryptophane by the fractional recrystallization of the quinine salt of acetyl racemic tryptophane from methyl alcohol. From each of the two products, the quinine was removed by means of alkali, and the acetyl group by acid hydrolysis.

J. S. H.

Pharmacology of Phenol Esters "Ginger Paralysis."—Early in 1930, a number of cases of so-called "ginger paralysis" occurred in many sections of the United States. The poisoning was ascribed to the action of triorthocresyl phosphate which had been used as an adulterant of the fluid extract of ginger ingested by the victims. MAURICE I. SMITH, E. W. ENGEL, AND E. F. STÖHLMAN (*Nat. Inst. Health Bul.* No. 160, 1–53, 1932) have made an extensive study of the pharmacology of twelve esters derived from various phenols. Of these esters, only three (triphenyl phosphate, triorthocresyl phosphate, and triorthocresyl phosphite) possessed specific neurotoxic properties, i.e. had a selective action more or less limited to certain well-defined physiological units of the nervous system, in which they produced degenerative changes. After a latent period, these changes became manifest in the form of characteristic sequelæ. A detailed description of the minute changes produced by these poisons in the nerve cells and the nerve tracts is given by R. D. LILLIE AND MAURICE I. SMITH (*Nat. Inst. Health Bul.* No. 160, 54–62, 1932).

J. S. H.

Iodine in Phosphate Rock.—W. L. HILL AND K. D. JACOB (*Jour. Asso. Offi. Agri. Chem.*, 1933, XVI, 128–137) have determined the iodine content of 40 samples of natural phosphates from various deposits in the United States and abroad. The iodine content, expressed in parts per million, ranged between 0.8 and 130. These rocks have a considerably higher iodine content than other rocks. Phosphates deposited during the Tertiary period are richest in iodine.

J. S. H.

Use of Catalysts in the Kjeldahl Method for the Quantitative Determination of Nitrogen.—The Kjeldahl method for the determination of nitrogen is used extensively by agricultural, biological, and industrial chemists. Various catalysts have been used in this method; and R. A. OSBORN AND ALEXANDER KRASNITZ (*Jour. Asso. Offi. Agri. Chem.*, 1933, XVI, 110–113) have made a comparative study of certain of these catalysts: Selenium, selenium oxychloride, mercuric oxide, and cupric sulphate. They find that selenium or its oxychloride has a slight advantage over cupric sulphate, but no advantage over mercuric oxide. Percipitated selenium is more suitable and more economical than its oxychloride. A combination of selenium with either uric sulphate or mercuric oxide, preferably the latter, has a great advantage over any of these catalysts used alone.

J. S. H.

Color Reaction of Beta Naphthol and Copper.—CHARLES C. FULTON (*Am. Jour. Pharm.*, 1933, CV, 62–63) reports that an ammoniacal solution of beta naphthol in dilute alcohol becomes a cloudy yellowish green in the presence of a cupric salt. The test is sensitive to 1 part of copper in 3,000,000.

J. S. H.

Color Reaction of Aspirin, Salicylic Acid and Manganese.—CHARLES C. FULTON (*Am. Jour. Pharm.*, 1933, CV, 59–61) describes a reaction between manganous salts and either solicylic acid or aspirin (acetylsolicylic acid) in the presence of ammonia and hydrogen peroxide with the formation of a pink or red color, changing to brown.

J. S. H.

Atomic Weight of Arsenic.—GREGORY P. BAXTER, WILLIAM E. SHAEFER, MERRILL J. DORCAS AND EDWARD W. SCRIPTURE, JR. (*Jour. Am. Chem. Soc.*, 1933, LV, 1054–1066) have determined the atomic weight of arsenic by the analysis of arsenic trichloride and arsenic tribromide, and the measurement of the ratio of the halide of arsenic to silver. They find the atomic weight of arsenic to be 74.91.

J. S. H.

Micro Determination of Chlorides.—LAWRENCE T. FAIRHALL AND J. WILLIAM HEIM (*Jour. Am. Chem. Soc.*, 1933, LV, 968–970) have devised a volumetric method for the determination of chlorides in liquids. The volume of the sample may be as little as 0.1 cc., and a fraction of a milligram of chloride may be determined with an accuracy of approximately 2 per cent. The entire procedure is carried out in a centrifuge tube (capacity 15 cc.) without filtration. If protein be present, it is precipitated by addition of tungstic acid and centrifugation. The chloride ion is then precipitated by addition of a definite volume of a solution of silver nitrate in dilute nitric acid; each cc. of this solution contains silver nitrate chemically equivalent to 1 milligram of sodium chloride; and excess of this solution must be added. The silver chloride which precipitates is deposited by centrifugation. The excess of silver ions is then titrated with a standard solution of potassium iodide of one-half the equivalent strength of the silver nitrate solution. When within a few drops of the endpoint, a buffer solution containing sodium nitrite and sodium citrate, and an indicator (starch paste) are added; the precipitated silver iodide is deposited by centrifugation; and the titration is finished with the potassium iodide solution, the end point

being a faint permanent blue color on looking down through the tube.

J. S. H.

Engineering Progress in 1932. Housing.—(*Eng. News-Record*, 110, 35.) Large-scale low-cost housing became a focal point of widespread interest during the year. Although no actual construction has yet been carried out, the projects receiving close study numbered almost 100. The reason for so much interest being shown in this phase of construction is laid to the Relief Act which listed housing projects as self-liquidating and eligible for loans. There has also been throughout the country a pronounced interest and more than ordinary activity in modernization and reconstruction of buildings, homes and apartment houses. Much of this activity originated in the fact that financial institutions, acquiring ownership through foreclosures, endeavor to make the structures produce increased revenue.

Engineering Progress in 1932. Building Activity.—(*Eng. News-Record*, 110, 35.) The outstanding example in the field of private enterprise is the Rockefeller Center, New York. Work on this project has proceeded at top speed during the past year. Under public construction may be included the work on government buildings in Washington, D. C. and on various federal courts and post-offices throughout the country. The few office buildings that were built all seemed to introduce some structural innovation. The 67-story Cities Service Building in New York not only became the third tallest building in the world but is more noted for its pioneer installation of double-deck elevators. In Philadelphia the new Savings Fund Society Building affords an example of unusual architecture; the air for the entire building is conditioned for moisture, temperature and cleanliness. The Gulf Oil Building in Pittsburgh, completed during the year, utilized unusually long-span floor framing of double girders to eliminate practically all columns in the rentable areas. In Chicago the buildings for A Century of Progress represent a studies attempt to make them unusual in appearance and economical in first cost. The architecture is dominated by plain facades, devoid of windows.

Engineering Progress in 1932. Bridges.—(*Eng. News-Record*, 110, 35.) During the past year only two or three new projects of large size were begun. Most of the activity centered in the completion of those started previously. Among these are the George Westinghouse Bridge at Pittsburgh whose 460-ft. center span is the

longest concrete arch in America; the 547-ft. Tyngsborough steel arch, the largest in Massachusetts; the Arlington Memorial Bridge in Washington, D. C.; the Rogue River Bridge in Oregon consisting of a series of concrete arches constructed according to the Freyssinet method of decentering and stress adjustment; and the South Tenth St. Bridge in Pittsburgh which is the first wire-cable suspension in that city of many bridges.

In San Francisco contracts were let for the 4,200-ft span Golden Gate suspension bridge. Plans were made for bids on the Bay Bridge between San Francisco and Oakland which in its 7½ miles will include two consecutive 2,310-ft. suspension spans with intermediate anchorage sunk in deep water, a 1,400-ft. cantilever span and a double-deck tunnel accommodating a 60-ft. roadway. The Albany-Rensselaer highway bridge over the Hudson includes a 341-ft. lift span weighing 2,750 tons exclusive of counterweights, the heaviest yet built.

A new record length was set for welded bridges by a 161-ft. span through truss in Czechoslovakia. An 1,850-ft. transporter suspension span is being constructed for the World's Fair in Chicago.

Engineering Progress in 1932. Structural Advance.—(*Eng. News-Record*, 110, 35.) Few analytical methods of design have excited so much interest or obtained so large a following in a short time as the Cross method of fixed-end moment distribution. Lightweight floors, both for buildings and bridges, enjoyed considerable favor during the past year. A pressed-steel floor of hollow beam units was utilized in a warehouse in Pittsburgh. For bridges, floors of open steel mesh of interlocking steel channels with asphalt-plank wearing surface and of concrete-filled steel grids were tried.

Among other advances are the development of welded trusses in which continuous straps are utilized as tension members, each strap forming two web members and a portion of the bottom chord; the design and fabrication of penstocks and tunnel linings 30 ft. in diameter with 2⅞-in. shell thickness, welded along longitudinal and ring seams, for the Hoover Dam penstock tunnels.

Engineering Progress in 1932. Research.—(*Eng. News-Record*, 110, 35.) Although lack of funds have handicapped research activities, some important results have nevertheless been recorded. Concrete column tests at Lehigh University and the University of Illinois were virtually completed and the results published. Some of the conclusions promise to affect design practice materially. A study of cements was conducted with a view to developing a material of low total heat generation for use in the Hoover Dam. This has

resulted in a product with less tricalcium silicate and more dicalcium silicate than standard portland and a minimum of tricalcium aluminate.

As a guide to design procedure for the suspension spans of the Bay Bridge at San Francisco, steel models nearly 100 ft. long were used. A special musical tensometer proved useful in determining variation of suspender pulls. In Cleveland statically indeterminate stresses in a novel steel parabolic arch of high rise having lateral bracing only in a relatively short length near the crown were determined by direct measurement on a celluloid model.

Weld structure is receiving more scientific attention than ever before. Some pioneer tests of corrosion fatigue of weld metal were made at Lehigh University. The rigidity of welded beam-to-column connections was the subject of research at the University of Toronto. At Purdue University stress distribution in welded butt-strap joints was the subject of an extensive investigation.

Engineering Progress in 1932. Water Power Changes.—(*Eng. News-Record*, **110**, 35.) Additions to the available water power were made through completion of the initial installations in such plants as that at Rock Island on the Columbia River, Safe Harbor on the Susquehanna, Beauharnois on the St. Lawrence and Chats Falls on the Ottawa. The 84,000-hp. turbines for Dnieprastroy, Russia were the largest built when they were installed but will soon be exceeded by the turbines at Hoover Dam at least five of which will have 115,000-hp. capacity each. The past year saw an increase in the head used on Kaplan (automatically adjustable blade propeller) turbines, one designed to operate under a head of 106 ft. having been ordered for the Shannon plant in Ireland.

Engineering Progress in 1932. Transportation Problems.—(*Eng. News-Record*, **110**, 35.) Important innovations on the technical side of railroad development were: an entirely new type of passenger car for branch-line service; an experimental car for suburban service having the passenger capacity greatly increased by seats placed at two levels; further extension of aluminum to the construction of freight-car bodies to save weight; and the further application of air-conditioning to passenger-train service. The new cars for branch-line service have wheels equipped with pneumatic tires and bodies fabricated of thin formed plates of stainless steel.

Engineering Progress in 1932. Road Construction.—(*Eng. News-Record*, **110**, 35.) Continuous improvement of road structure

and road building processes characterized the highway construction of the past year as it has for a dozen years past. A revival of the old Hassom cement—penetration macadam construction and experimentation with an analogous cement-bound stone construction, using a new bitumized cement, constitute the nearest approach to new road types. For both bituminous and brick-surfaced roads a decided improvement was shown in concrete-base design to reduce cracking. Paving-brick manufacturers have introduced a de-aired brick, having greater strength and density. Bituminous materials increased their usefulness in the lower-cost road field by virtue of better control of materials, more careful construction procedure and increased mechanization.

Single-Vane Wind Turbine.—(*Power*, **77**, 62.) Low-cost electrical energy for advertising signs and similar low loads at points of sustained air circulation is possible by this wind turbine, using a stainless steel hollow air-foil vane fabricated by the shot-welding process. One particular model is a 1-Kw unit with the generator mounted on the mill shaft and operating through a 9–1 step-up gear. The speed is practically constant at 120 r.p.m. for all wind velocities above 15 m.p.h. attained by the automatic feathering of the single balanced vane.

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